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CATALOGUE
OF THE
PERCY COLLECTION
OF
METALLURGY
IN THE
SOUTH KENSINGTON MUSEUM.

Department of Science and Art of the Committee of
Council on Education.

CATALOGUE

OF THE

COLLECTION OF METALLURGICAL SPECIMENS

FORMED BY THE LATE

JOHN PERCY, ESQ., M.D., F.R.S.,

NOW IN THE

SOUTH KENSINGTON MUSEUM,

BY PROFESSOR J. F. BLAKE, M.A., F.G.S.

WITH AN INTRODUCTION

BY PROFESSOR ROBERTS-AUSTEN, C.B., F.R.S.

LONDON:
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INTRODUCTION.

It is not a little remarkable that while cabinets of minerals, both public and private, are to be found in every important town, but few collections have been made of the metallurgical specimens which illustrate the processes employed, either in extracting metals from their ores or in fitting them for use.

Of the nature and extent of ancient industrial collections but little is known. Bernard Palissy, who died late in the 16th century (1589), insisted on the importance of providing them, and formed one himself. Georgius Agricola, the author of the first systematic treatise on metallurgy (1556), who shared with Palissy the leading position as exponent of industrial chemistry, certainly possessed a metallurgical cabinet, which is known to have been an extensive one, but how far this, the collection of the leading metallurgist of his day, was representative, may be gathered from the fact that it did not contain a specimen of zinc, which had been known for two centuries, although the metal was still rare.

Even so late as the first half of the present century, public collections of metallurgical specimens were far from being numerous. The National one, newly formed when the museum in Jermyn Street was opened in 1851, was described by Dr. Percy in 1854 as being "already "of considerable value," and as destined to "become "one of the most perfect in Europe."

He also referred to a private collection which he had himself been engaged in forming during the previous twelve years, as containing "numerous examples of the "defects which occur from time to time in the working

" of certain metals, and frequently depend upon the " presence of foreign bodies, in minute proportions, " which have escaped the attention of the smelter." Towards the close of his life, in his inaugural address as President of the Iron and Steel Institute (1885), he again referred to his very large collection, from the study of which he had derived much instruction. Dr. Percy began to form this in 1842, and at the time of his death in 1889 it comprised over 4,000 specimens, besides a very numerous miscellaneous series of metals and alloys. The value of the collection was well known, and as Dr. Percy's family wished that it should be preserved in connection with the school where he had so long taught, a careful examination of the specimens was made by my colleague, Professor Judd, and myself, and we unhesitatingly recommended its purchase. We further suggested that the services of Professor J. F. Blake should be secured for cataloguing and arranging the specimens.

From the entire series, 3,700 specimens were selected. These were all accompanied by descriptive labels written by Dr. Percy's own hand, each label bearing testimony to his laborious care and minute accuracy. The value of the collection is indicated by the fact that the specimens practically illustrate his classical treatise on Metallurgy, and the labels in many cases refer to the pages in his work where the specimens are described, to the specification of a patent with which they are connected, or to a monograph which they illustrate.

A large number of the specimens have been completely analysed; the results are stated in the catalogue, and in most cases the per-centage amount is given of the particular constituent from which the interest is derived. Many of the specimens illustrate processes which are now antiquated or even obsolete, while others represent processes of which it is very difficult to obtain complete typical illustrations. As an instance of the latter might be cited those which show the various stages of the "kernel roasting" of cupriferous iron pyrites, with a view to concentrate the copper in a central kernel of each lump of ore. Another series of interest is that showing some of the results of Sir James Hall's well known experiments on the effect of heat and compression on various substances. These formerly belonged to Faraday, and are labelled by him. Among the samples of metals prepared for industrial use, the series illustrating the wearing of copper sheathing which has been employed in Her Majesty's Navy, may be specially mentioned.

Many as yet undescribed alloys will be found in the collection, and suggest a wide field of laboratory research, whilst its richness in ores and fuels makes it of great value to the miner.

The series, as a whole, may be described as the most interesting of its kind in the world. The admirable metallurgical collection exhibited in the United States National Museum at Washington, is of such recent date, that, although it contains nearly the same number of specimens as the Percy collection, it has but little antiquarian interest. Many of the continental museums are rich in specimens illustrating the investigations of the earlier metallurgists, but no collection can compare with Dr. Percy's, either in historical importance, in scientific interest, or in educational value.

It should be added that Professor Blake's labour in arranging and cataloguing has necessarily been considerable; all who study the specimens will greatly appreciate the care and thoroughness with which he has performed his task.

W. C. ROBERTS-AUSTEN.

December 1891.

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CATALOGUE OF THE COLLECTION OF METALLURGICAL SPECIMENS FORMED BY THE LATE DR. PERCY, F.R.S.

FUELS.

FUELS OF MODERN ORIGIN.

1. Sample of decayed oak wood. Analysed by W. J. Ward.

Carbon	43·59
Hydrogen	4·82
Oxygen and Nitrogen	36·78
Ash	5·12
Water	9·69
	100·00

See Percy's Metallurgy, Fuel, p. 186.

2. Brown peat from Ireland.

From the Bog of Allen. It has been triturated with water. Communicated by J. R. Wigham.

3. Black peat from near Maryboro', Ireland. Air dried.

From a bog on the Great North-Western Railway. Communicated by J. R. Wigham.

4. Brown peat from Ireland compressed into a cylindrical shape by hydraulic machinery.

Communicated by J. R. Wigham.

5. Peat cut from near the surface. Showing its uncompressed state, with the remains of the *sphagnum* of which it is composed still visible.

6. Air dried compressed peat, by Clayton's patent process (1875).

See Specification No. 2975, 1872. Communicated by H. Bauerman.

7. Round ball of compressed peat.

8. Round ball of compressed material made of one-half peat, and one-half slack coal.

9. Black peat from the lowest part of the deposit.

Very dry. Communicated by Professor Goodeve. Analysed by W. J. Ward.

10. Hanoverian peat. No. 1 is from near the surface. No. 2 from deeper layers.

See Percy's Metallurgy, Fuel, p. 220. Communicated by Mr. Hedley.

11. Two samples of German peat from the newest peat formation.

The brown variety shows remains of the twigs and roots, and is from the top of the deposit. The black variety shows them more feebly.

12. Ereiniog prepared peat, from Portmadoc, and specimen of charcoal made from the same.

This peat yields on an average 27·3 per cent. of charcoal. Examined by R. Smith, 1875.

13. Peat from Cashmere (formed in a lake) from the aquatic plants but not from any species of sphagnum.

Communicated by Dr. Falconer.

14. Compressed peat, as used on some sections of the Canadian Pacific Railway.

Communicated by G. M. Dawson.

15. Boa constrictor's dung, used as a fuel for smelting in the East.

LIGNITES AND BROWN COALS.

16. Lignite from Bovey Tracey, Devonshire. A deposit of Tertiary (Eocene) age.

The variety called "board coal" yields after air-drying 52·37 per cent. of coke containing 29·98 per cent. of ash. *See* Percy's Metallurgy, Fuel, p. 313. Communicated by Mr. Pengelly.

17. Resin coal occurring in association with the lignite of Bovey Tracey, Devonshire.

A compact brown mass.

18. Lignite from Suderoe. Faroe Islands. In Miocene Basalt. Exhibited by the Danish Government in the Paris Exhibition, 1878.

Brilliant, black, in broad and narrow bands.

19. Lignite from the Island of Majorca. Contains *Planorbis* and other freshwater shells, believed to be of Tertiary age Analysed by C. Tookey.

Carbon - - - -	51·61
Hydrogen - - - -	4·11
Oxygen and Nitrogen - - -	9·06
Sulphur - - - -	7·87
Ash (grey) - - - -	17·25
Water - - - -	10·10
	100·00

No pyrites visible. This black lignite occurs in bands interstratified with light coloured bituminous shales, examples of which here accompany it.

See Percy's Metallurgy, Fuel, p. 319.

20. Black lignite from Cebu, Philippine Islands. Age undetermined. Analysed by C. Tookey.

Carbon	55·42
Hydrogen	4·20
Oxygen and Nitrogen	15·43
Sulphur	2·25
Ash	7·00
Water	15·70
	100·00

See Percy's Metallurgy, Fuel, p. 318.

21. Lignite from Desolation Island, part of the Kerguelen group.

It is much broken up by thin veins of a zeolitic mineral containing lime. Analysed by C. Tookey.

	Including veinstuff.	Excluding veinstuff.
Carbon	41·59	48·07
Hydrogen	3·61	3·88
Oxygen and Nitrogen	14·68	16·95
Sulphur	0·57	
Ash	27·50	17·05
Water	12·05	14·05
	100·00	100·00

See Percy's Metallurgy, Fuel, p. 318. Communicated by the Admiralty.

22. Black lignite from Kukaghatch, Asia Minor; of Tertiary age. Produces 50·08 per cent. of granular and non-coherent coke. Analysed by W. J. Ward.

Carbon	56·69
Hydrogen	4·36
Oxygen and Nitrogen	15·94
Sulphur	0·48
Ash	8·80
Water	13·73
	100·00

See Percy's Metallurgy, Fuel, p. 319.

23. Lignite from Nicaragua. Analysed by W. J. Ward.

Carbon	58·16
Hydrogen	5·13
Oxygen and Nitrogen	14·89
Sulphur	0·63

Water	18·24
Ash	2·95
	100·00

See Percy's Metallurgy, Fuel, p. 320. Communicated by Hart and Company.

24. Shaly lignite from Nicaragua.

Communicated by C. Bedford Pim. Analysed by W. J. Ward.

25. Lignite from Venezuela. Analysed by W. J. Ward. Yields 52·54 per cent. of coke.

Carbon	42·16
Hydrogen	3·46
Oxygen and Nitrogen	17·45
Sulphur	3·45
Ash	5·69
Water	12·37
Bisulphide of iron	4·78
Sulphate of iron	10·64
	100·00

See Percy's Metallurgy, Fuel, p. 321. A disintegrated mass like decayed wood. Communicated by J. Bedford Pim, 1866.

26. Lignite from Lota, on the coast of Chili, 250 miles south of Valparaiso. Analysed by W. J. Ward.

Carbon	47·15
Hydrogen	3·61
Oxygen and Nitrogen	12·80
Sulphur	1·51
Ash	15·58
Water	19·35
	100·00

Produces 47 per cent. of coke. *See* Percy's Metallurgy, Fuel, p. 321. Communicated by A. J. Duston, 1873.

27. Lignite, with resin occurring in it, from Auckland, New Zealand.

The resin is diffused throughout in pieces from the size of a pea upwards. Analysed by C. Tookey in bulk.

Carbon	55·57
Hydrogen	4·13
Oxygen	15·67
Nitrogen	1·15
Sulphur	0·36
Ash	9·00
Water	14·12
	100·00

See Percy's Metallurgy, Fuel, p. 317. Communicated by Governor Denison.

28. Lignite, with diffused resin from Tasmania. Analysed by C. Tookey, in bulk.

Carbon - - - -	59·90
Hydrogen - - - -	4·66
Oxygen - - - -	15·99
Nitrogen - - - -	1·08
Sulphur - - - -	0·30
Ash - - - - -	4·64
Water - - - - -	13·43
	100·00

The resin is in small opaque honey-yellow masses which yield on combustion 81·60 per cent. carbon and 11·06 per cent. hydrogen. *See* Percy's Metallurgy, Fuel, p. 317. Communicated by Governor Denison.

29. Compact lignite from Toepletyz, Bohemia.

Compare Percy's Metallurgy, Fuel, p. 314. Communicated by Mr. Casella.

30. Lignite from the right bank of the Saskatchewan River at Fort Edmonton; 6 ft. seam; lat. 53° 33′ N.; long. 113° 30′ W. Of lower Cretaceous age. Broken up by exposure to the air. Analysed by C. Tookey.

Carbon - - - -	50·60
Hydrogen - - - -	3·24
Oxygen - - - -	14·41
Nitrogen - - - -	0.90
Sulphur - - - -	0·42
Ash - - - - -	15·93
Water - - - - -	14·50
	100·00

See Percy's Metallurgy, Fuel, p. 316. Communicated by Dr. Hector.

31. Lignite from the right bank of the Saskatchewan River at Fort Edmonton. Of Cretaceous age. (*See* No. **30.**)

A solid black resinous, bedded mass.

32. Lignite from San Pete county, Utah State, Western Territories of America. Probably of Cretaceous age.

Accompanied by a piece of coke produced from it. *See* Coal Commissioners' Report, Vol. III., p. 247. Very dull and fine banded.

33. Lignite from Goneza Iglesias, west of Cagliari, I. of Sardinia. Probably of Carboniferous age. Analysed by C. Tookey.

Carbon - - - -	50·80
Hydrogen - - - -	4·03
Oxygen and Nitrogen - - -	6·92

Sulphur - - - -	10·81
Ash - - - - -	21·28
Water - - - - -	6·16
	100·00

See Percy's Metallurgy, Fuel, p. 315. Communicated by Sig. Semenza, 1862.

34. Lignite from the Dranista Coalfield, near Katerina, on the west side of the Gulf of Salonika. The 16 inch vein analysed by W. J. Ward.

Carbon - - - -	47·11
Hydrogen - - - -	3·19
Oxygen and Nitrogen - - -	15·05
Sulphur - - - -	0·72
Ash - - - - -	14·25
Water - - - - -	19·68
	100·00

See Percy's Metallurgy, Fuel, p. 316. Communicated by B. Baker, 1874.

35. Lignite from the Dranista Coalfield, "Laca" bed. Analysed by W. J. Ward.

Carbon - - - -	46·40
Hydrogen - - - -	3·36
Oxygen and Nitrogen - - -	12·04
Sulphur - - - -	2·72
Ash - - - - -	15·88
Water - - - - -	19·60
	100·00

See Percy's Metallurgy, Fuel, p. 316. Communicated by B. Baker, 1874.

36. Brown lignite from the Dranista Coalfield, "Demolaca" bed. Analysed by W. J. Ward.

Carbon - - - -	46·47
Hydrogen - - - -	3·84
Oxygen and Nitrogen - - -	12·99
Sulphur - - - -	1·87
Ash - - - - -	18·10
Water - - - - -	16·73
	100·00

See Percy's Metallurgy, Fuel, p. 316. Communicated by B. Baker, 1874.

37. Shaly lignite from the Dranista Coalfield, "Panaya" bed. Analysed by W. J. Ward.

Carbon	45·69
Hydrogen	4·02
Oxygen and Nitrogen	12·12
Sulphur	2·52
Ash	19·20
Water	16·45
	100·00

See Percy's Metallurgy, Fuel, p. 316. Communicated by B. Baker, 1874.

38. Lignite from Dranista Coalfield, "Loftacarria" bed. Analysed by W. J. Ward.

Carbon	46·47
Hydrogen	3·44
Oxygen and Nitrogen	15·38
Sulphur	0·80
Ash	15·07
Water	18·84
	100·00

See Percy's Metallurgy, Fuel, p. 316. Communicated by B. Baker, 1874. A banded black coal, like an ordinary bituminous one.

39. Lignite from Sasso Forte, Italy. Analysed by W. J. Ward.

Carbon	64·31
Hydrogen	4·69
Oxygen and Nitrogen	12·40
Sulphur	1·82
Ash (grey)	8·48
Water	8·30
	100·00

See Percy's Metallurgy, Fuel, p. 316. It yields no coke, but 56·61 per cent. of a carbonised non-coherent residue, and 35·09 per cent. of volatile gaseous matter. It breaks into small black fragments. Communicated by J. Brunton, 1874.

40. Brown coal from Bromberg, Saxony. Heated up to a certain point, and compressed in cylinders, but still has the aspect of compressed peat.

Communicated by the Zollverein Department of the Exhibition of 1862.

41. Pirnie brown coal.

Very brown and wood-like.

42. Pirnie black coal.

Like an ordinary cannel coal.

43. Lignite from Sehnde, Hanover; of Wealden age. Analysed by W. J. Ward.

Carbon	52·53
Hydrogen	4·10
Oxygen and Nitrogen	10·57
Sulphur	2·05
Ash	17·70
Water	13·05
	100·00

See Percy's Metallurgy, p. 336. A brown earthy mass.

44. Lignite from Portree Harbour, Skye, lying between sheets of lava; of Miocene age. Analysed by W. J. Ward.

Carbon	68·90
Hydrogen	5·67
Oxygen and Nitrogen	12·85
Sulphur	0·33
Ash	5·40
Water	6·85
	100·00

It is black and dull, and breaks in small pieces. It yields 51·74 per cent. of carbonaceous residue and 41·41 per cent. of volatile matter.

45. Shaly lignite from Zagola, in Corinth; of Tertiary age.

Communicated by A. Lennox.

46. Shaly lignite from Megalopolis, Arcadia, in the valley of Alpheus, Greece; of Tertiary age.

Communicated by A. Lennox.

47. Shaly lignite from Kumi, in Eubœa, Greece; of Tertiary age.

Communicated by A. Lennox.

48. Shaly lignite from Kalamaki, near the Isthmus of Corinth; of Tertiary age.

Communicated by A. Lennox.

49. Lignite from Germany. Analysed by W. J. Ward.

Carbon	46·50
Hydrogen	3·23
Oxygen and Nitrogen	17·54
Sulphur	2·70
Ash	12·65
Water	17·38
	100·00

It is a black compact coal, yielding 40·90 per cent. of carbonaceous residue and 41·72 per cent. of volatile matter. Communicated by J. Simpson.

50. Brown coal from Brazil. Occurs in great quantity about 70 miles south of Bahia on a navigable river, and about 12 miles from the sea.

A brown resinous looking substance. Communicated by J. D. Sargent.

51. Dark, brown, woody lignite from Hesse Cassel. Yields 47·50 per cent. of coke. Analysed by C. Tookey.

Carbon - - - -	62·18
Hydrogen - - - -	4·42
Oxygen and Nitrogen - - -	19·21
Sulphur - - - -	0·71
Ash - - - - -	2·03
Water - - - - -	11·45
	100·00

See Percy's Metallurgy, Fuel, p. 315.

52. Dull, black, coal-like lignite from Panama.

Communicated by Sir George Elliott, 1871.

53. Four samples of "Fuels" from Trinidad.

One of these labelled "6" has the appearance of lignite, the one labelled "15" is dull and pitch-like, that labelled "17" is more shaly, and that labelled "18" is soft like asphalt. They are all said to be analysed by C. Tookey. Communicated by Mr. Bonnycastle.

Four samples of "lignite" from Trinidad are mentioned in Dr. Percy's Metallurgy, Fuel, p. 316, where the following analyses are given :—

——	I.	II.	III.	IV.
Carbon - - - - -	60·13	69·53	57·38	56·19
Hydrogen - - - -	4·14	5·36	3·74	4·14
Oxygen and Nitrogen - -	10·77	15·22	17·50	17·39
Sulphur - - - -	2·36	0·55	0·68	2·23
Ash - - - -	2·10	3·44	3·90	2·40
Water - - - -	20·50	5·90	16·80	17·65
	100·00	100·00	100·00	100·00

These doubtless refer to the above specimens, but there is nothing to show their individual correspondence.

BITUMINOUS SUBSTANCES AND OIL SHALES.

54. Natural asphalt from the Pitch Lake of Trinidad.

A solid dull mass. Communicated by Mr. Bonnycastle.

55. Boiled asphalt from the Pitch Lake of Trinidad.

More compact and pitch-like. Communicated by Mr. Bonnycastle.

56. Carbonaceous substance occurring in pieces of various sizes, lying on the sandy soil of the desert, Australia.

A light porous crumbly substance, which burns readily to an ash, and contains a large quantity of highly carbonaceous gas or oil. Communicated by J. D. Fortescue.

57. Elastic bituminous substance from Australia. Analysed by W. J. Ward in 1866.

Carbon	80·113
Hydrogen	11·744
Oxygen	7·077
Ash	0·664
Water	0·402
	100·000

Yields on distillation 59·2 per cent. of oil, 10 per cent. of water, and 16·3 per cent. of gaseous matter, leaving a residue of 14·5 per cent.

58. Resin from Botany Bay.

A light brown mass with signs of cellular structure.

59. Horn coal (? New South Wales).

A black compact mass, like cannel coal, which yields paraffin by distillation.

60. Hartley kerosene shale. Found in many parts of New South Wales.

A black lustrous lignite, which yields paraffin by distillation.

61. Oil shale from Scotch coalfields.

Yields 11·62 per cent. of oil, or 30 gallons to the ton. Two specimens: one duller, the other more like cannel coal. Communicated by the Right Hon. J. F. Kennedy.

62. Oil shale from Scotch coalfields.

Yields 23·9 per cent. of oil, or 65 gallons per ton. A compact mass, with slickensides of the appearance of fossils. Communicated by the Right Hon. J. F. Kennedy.

63. A black compact oil shale from Scotch coalfields.

Yields 4·72 per cent. of oil, or 13 gallons per ton. Communicated by C. W. Bell.

64. "Plane shale" from Scotland.

Yields 12·7 per cent. of oil, or 35 gallons per ton. Small fragments of a dark grey shale. Communicated by J. Pender.

65. "Curley shale" from Scotland.

Yields 14·5 per cent. of oil, or 39 gallons per ton. Similar to the "Plane shale." Communicated by J. Pender.

66. Petroleum earth.

Yields 5·46 per cent. of oil, or 15 gallons per ton.

67. Shale from Rugby.

Yields 21·7 per cent. of oil, or 58 gallons per ton. Contains 1·59 per cent. of sulphur. It is in small flat pieces, exactly resembling some of the jet rock shale of Whitby, which is also sulphur bearing.

68. Stellar oil coal. Stellarton, Pictou County.

69. Albertite. Nova Scotia.

Occurs in fissures in Carboniferous rocks. Carbon 82·67. Hydrogen 9·14. Oxygen and Nitrogen 8·19. *See* Percy's Metallurgy, Fuel, p. 331. Very brilliant and glassy looking. From the Exhibition of 1862.

70. Albertite from Kittram parish, Ross-shire, Scotland.

See Percy's Metallurgy, Fuel, p. 391. Very glassy looking. Communicated by A. C. Mackenzie.

71. Petroleum oil cannel coal from New South Wales.

Shale Oil Co.'s Mine, Hartley, 80 miles S. of Sydney. A 3 ft. 6 in. seam yields 150 gallons of crude oil per ton and 18,000 cubic ft. of gas. Entirely compact without grain, with silky lustre and conchoidal fracture. Communicated by J. Mackenzie, 1873.

72. Petroleum oil cannel coal from the outcrop of the bed mined at Bathgate near Wallerawang, New South Wales.

Two beds 14 in. thick are contained in 6 ft. and yield 17,500 cubic ft. of gas per ton. Dull, earthy, quite compact, entirely without grain. Communicated by J. Mackenzie, 1873.

73. Bitumen from Cape Paterson, Victoria, New South Wales.

A solid bright, soft, brittle mass.

74. Bituminous shale called "Kimeridge coal."

It occurs in the midst of the Kimeridge clay in Kimeridge Bay on the south coast of England, where it has been known to take fire spontaneously. It burns with a yellow flame when heated.

BRITISH COALS.

75. Peareth gas coal from Springwell Colliery, Northumberland. Analysed by A. Dick, after desiccation.

Carbon	82·42
Hydrogen	4·82
Oxygen and Nitrogen	11·11
Sulphur	0·86
Ash	0·79
	100·00

A brilliant black coking coal with a hackly fracture. *See* Percy's Metallurgy, Fuel, p. 322.

76. Nant-y-glo and Blaina coal, No. 1. The old coal, or Lower 4-feet seam. Analysed by W. J. Ward.

Carbon	83·74
Hydrogen	4·83
Oxygen and Nitrogen	3·72
Sulphur	1·01
Ash (pale red)	6·02
Water	0·68
	100·00

Black and splintering into small fragments. Yields 78·12 per cent. of firm lustrous coke. *See* Percy's Metallurgy, Fuel, p. 569.

77. Nant-y-glo and Blaina coal, No. 2. Top grain or three-quarter coal. Analysed by W. J. Ward.

Carbon	84·75
Hydrogen	4·82
Oxygen and Nitrogen	4·79
Sulphur	0·14
Ash (reddish grey)	4·85
Water	0·65
	100·00

A black splintering coal, yielding 75·52 per cent. of firm lustrous coke. *See* Percy's Metallurgy, Fuel, p. 570.

78. Nant-y-glo and Blaina coal, No. 3. Big vein. Analysed by W. J Ward.

Carbon	84·44
Hydrogen	5·00
Oxygen and Nitrogen	4·23
Sulphur	0·81
Ash (pinkish grey)	4·87
Water	0·65
	100·00

A black splintering coal, yielding 74·60 per cent. of firm lustrous coke. *See* Percy's Metallurgy, Fuel, p. 570.

79. Nant-y-glo and Blaina coal, No. 4. Elled vein. Analysed by W. J. Ward.

Carbon	83·64
Hydrogen	4·64
Oxygen and Nitrogen	5·76
Sulphur	0·75
Ash (reddish grey)	4·55
Water	0·66
	100·00

A black and lustrous small splintering coal, yielding 73·22 per cent. of firm lustrous coke. *See* Percy's Metallurgy, Fuel, p. 570.

80. The first part of 10-yard coal from Whyley Colliery, South Staffordshire, called "Rooves." Analysed by A. Dick, after desiccation.

Carbon	76·12
Hydrogen	4·83
Oxygen and Nitrogen	15·72
Sulphur	1·00
Ash	2·33
	100·00

See Percy's Metallurgy, Fuel, p. 325. A compact non-caking coal.

81. The second part of 10-yard coal from Whyley Colliery, South Staffordshire, called "Top Slipper." Analysed by A. Dick, after desiccation.

Carbon	77·01
Hydrogen	4·71
Oxygen and Nitrogen	15·98
Sulphur	0·74
Ash	1·56
	100·00

See Percy's Metallurgy, Fuel, p. 325. A splintering non-caking coal.

82. The third part of 10-yard coal from Whyley Colliery, South Staffordshire, called "White coal." Analysed by A. Dick, after desiccation.

Carbon	76·40
Hydrogen	4·62
Oxygen and Nitrogen	16·88
Sulphur	0·55
Ash	1·55
	100·00

See Percy's Metallurgy, Fuel, p. 325. A fine splintering non-caking coal.

83. The fifth part of 10-yard coal from Whyley Colliery, South Staffordshire, called "Brazil." Analysed by A. Dick, after desiccation.

Carbon	72·13
Hydrogen	4·32
Oxygen and Nitrogen	16·57
Sulphur	0·54
Ash	6·44
	100·00

See Percy's Metallurgy, Fuel, p. 325. A fine splintering non-caking coal. Used for reverberatory smelting furnaces.

84. Part of the 10-yard, or thick coal, from Grace May Colliery, Rowley Regis, South Staffordshire, called the "Foot" or "Sawyer" coal. Analysed by C. Law.

Carbon	68·40
Hydrogen	4·43
Oxygen and Nitrogen	10·28
Sulphur	1·05
Ash (buff)	8·91
Water	6·93
	100·00

See Percy's Metallurgy, Fuel, p. 570. A compact banded, irregular coal, scarcely caking.

85. Part of the 10-yard, or thick coal, from Grace Mary Colliery, Rowley Regis, South Staffordshire, called the "Lambs" or "Brazils" coal. Analysed by C. Law.

Carbon	67·34
Hydrogen	4·62
Oxygen and Nitrogen	11·68
Sulphur	0·62
Ash (buff)	8·00
Water	7·74
	100·00

See Percy's Metallurgy, Fuel, p. 570. A thin banded bright coal, scarcely caking.

86. "Heathen" or "Spin coal" below the 10-yard coal, from Grace Mary Colliery, Rowley Regis, South Staffordshire. Analysed by C. Tookey.

Carbon	70·41
Hydrogen	4·69
Oxygen and Nitrogen	12·47
Sulphur	0·71
Ash	2·20
Water	9·52
	100·00

See Percy's Metallurgy, Fuel, p. 327. A solid, compact, non-caking coal.

87. "Mother of coal" from the surface of the heathen coal.

88. "Upper Four-foot coal." Dowlais, S. Wales. Analysed by E. Riley, after desiccation.

Carbon	89·33
Hydrogen	4·43
Oxygen	3·25
Nitrogen	1·24
Sulphur	0·55
Ash	1·20
	100·00

See Percy's Metallurgy, Fuel, p. 328. A bright thin splintering non-caking coal used in blast furnaces.

89. "Rhes Las" or brassy coal. Dowlais, S. Wales. Analysed by E. Riley, after desiccation.

Carbon	88·13
Hydrogen	4·51
Oxygen	2·94
Nitrogen	1·41
Sulphur	1·01
Ash	2·00
	100·00

See Percy's Metallurgy, Fuel, p. 328. A small splintering non-caking coal used in forges.

90. "Bargoed Big coal." Dowlais, S. Wales. Analysed by E. Riley, after desiccation.

Carbon	87·62
Hydrogen	4·34
Oxygen	2·52
Nitrogen	1·13
Sulphur	1·07
Ash	3·32
	100·00

See Percy's Metallurgy, Fuel, p. 328. A small splintering non-caking coal used in blast furnaces.

91. "Tomo yard coal." Dowlais, S. Wales. Analysed by E. Riley, after desiccation.

Carbon	82·60
Hydrogen	4·28
Oxygen	3·44

Nitrogen - - - -	1·28
Sulphur - - - -	1·22
Ash - - - - -	7·18
	100·00

See Percy's Metallurgy, Fuel, p. 328. A thin banded non-caking coal, not good for blast furnaces.

92. Cannel coal. Kirkless Hall and Hendley Colliery, near Wigan, Lancashire.

93. Very compact Cannel coal. Channock Chase, Staffordshire.

Communicated by Mr. McClean.

94. Cannel coal. Dukinfield Colliery, Ashton-under-Lyne, Staffordshire. Analysed by C. Tookey.

Carbon - - - -	83·25
Hydrogen - - - -	5·75
Oxygen and Nitrogen - - -	5·06
Sulphur - - - -	0·86
Ash (grey) - - - -	3·48
Water - - - - -	1·60
	100·00

See Percy's Metallurgy, Fuel, p. 330. It yields 63·25 per cent. of coke and 35·15 per cent. of volatile gaseous matter.

95. Smooth Cannel coal. Leeswood Green Colliery, Mold, Flintshire. Analysed by C. Tookey.

Carbon - - - -	79·87
Hydrogen - - - -	5·78
Oxygen and Nitrogen - - -	8·09
Sulphur - - - -	0·57
Water - - - - -	2·84
Ash - - - - -	2·85
	100·00

See Percy's Metallurgy, Fuel, p. 330. It yields 43·40 per cent. of volatile gaseous matter.

96. Curley Cannel coal. Leeswood Green Colliery, Mold, Flintshire. Analysed by C. Tookey.

Carbon - - - -	77·81
Hydrogen - - - -	8·47
Oxygen and Nitrogen - - -	6·32
Sulphur - - - -	0·71
Water - - - - -	0·68
Ash - - - - -	6·01
	100·00

See Percy's Metallurgy, Fuel, p. 328. It yields 92·08 per cent. of volatile gaseous matter.

97. Cannel Coal. Leeswood Green Colliery, Mold, Flintshire.

A more earthy looking bed lying below No. **100** and yielding 30·50 per cent. of ash.

98. Seaton Burn steam coal, or Ravensworth West Hartley, from Seaton Burn Colliery, Northumberland. Analysed by A. Dick, after desiccation.

Carbon	78·65
Hydrogen	4·65
Oxygen and Nitrogen	13·66
Sulphur	0·55
Ash	2·49
	100·00

See Percy's Metallurgy, Fuel, p. 322. A non-caking coal.

99. Thick coal. Russell's Hall Colliery, Dudley, South Staffordshire.

The finest quality set aside for making smiths' coke. It is one of the brilliant bituminous bands in the coal.

100. Main coal. Broughton Coal Company, Wrexham, Denbighshire. Analysed by W. J. Ward.

Carbon	78·44
Hydrogen	5·27
Oxygen and Nitrogen	8·30
Sulphur	0·99
Ash	2·15
Water	4·85
	100·0

See Percy's Metallurgy, Fuel, p. 333. A dull thin banded coal, yielding 61·38 per cent. of coke.

101. Crank coal. Broughton Colliery, Wrexham, Denbighshire. Analysed by W. J. Ward.

Carbon	81·29
Hydrogen	4·53
Oxygen and Nitrogen	6·77
Sulphur	0·91
Ash	2·50
Water	4·10
	100·00

See Percy's Metallurgy, Fuel, p. 333. A very dull and earthy looking coal, yielding 68·80 per cent. of coke.

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102. Bituminous coal, No. 1. Risca Colliery, Newport, Monmouthshire. Analysed by W. J. Ward.

Carbon - - - -	80·08
Hydrogen - - - -	5·03
Oxygen and Nitrogen - - -	5·29
Sulphur - - - -	3·42
Ash (greyish white) - - -	5·05
Water - - - - -	1·13
	100·00

See Percy's Metallurgy, Fuel, p. 333. A banded coal, yielding 64·72 per cent. of firm and coherent coke.

103. Bituminous coal, No. 2. Risca Colliery, Newport, Monmouthshire. Analysed by W. J. Ward.

Carbon - - - -	75·49
Hydrogen - - - -	4·73
Oxygen and Nitrogen - - -	6·78
Sulphur - - - -	1·21
Ash (greyish white) - - -	10·67
Water - - - - -	1·12
	100·00

See Percy's Metallurgy, Fuel, p. 333. A compact banded coal, yielding 68·88 per cent. of firm and coherent coke.

104. "Cae David" coal. Tywith Colliery, Llynvi Valley, Bridgend, Glamorganshire. Used at the Tonddu Ironworks. Analysed by W. J. Ward.

Carbon - - - -	82·26
Hydrogen - - - -	5·28
Oxygen and Nitrogen - - -	5·96
Sulphur - - - -	1·25
Ash - - - - -	4·18
Water - - - - -	1·07
	100·00

See Percy's Metallurgy, Fuel, p. 334. A thin banded coal, yielding 66·38 per cent. of coke.

105. "Nine-foot" coal. Llynvi Coal and Iron Company, Bridgend, Glamorganshire. Analysed by W. J. Ward.

Carbon - - - -	87·61
Hydrogen - - - -	4·73
Oxygen and Nitrogen - - -	3·55
Sulphur - - - -	1·07
Ash - - - - -	2·38
Water - - - - -	0·66
	100·00

See Percy's Metallurgy, Fuel, p. 334. A thin banded, small splintering coal, yielding 79·90 per cent. of coke.

106. "Six-foot" coal. Llynvi Coal and Iron Company, Bridgend, Glamorganshire. Analysed by W. J. Ward.

Carbon - - - -	87·85
Hydrogen - - - -	4·67
Oxygen and Nitrogen - - -	3·77
Sulphur - - - -	1·07
Ash - - - - -	2·00
Water - - - - -	0·64
	100·00

See Percy's Metallurgy, Fuel, p. 334. A brilliant small splintering coal, yielding 79·72 per cent. of coke.

107. "Duffryn" coal. Llynvi Coal and Iron Company, Bridgend, Glamorganshire. Analysed by W. J. Ward.

Carbon - - - -	84·75
Hydrogen - - - -	4·65
Oxygen and Nitrogen - - -	5·04
Sulphur - - - -	0·76
Ash - - - - -	3·93
Water - - - - -	0·87
	100·00

See Percy's Metallurgy, Fuel, p. 334. A small splintering coal, yield ing 76·92 per cent. of coke.

108. "Cae David" coal. Llynvi Coal and Iron Company, Bridgend, Glamorganshire. Analysed by W. J. Ward.

Carbon - - - -	84·10
Hydrogen - - - -	4·76
Oxygen and Nitrogen - - -	3·79
Sulphur - - - -	1·28
Ash - - - - -	5·43
Water - - - - -	0·64
	100·00

See Percy's Metallurgy, Fuel, p. 334. A thick banded compact coal, yielding 76·12 per cent. of coke.

109. "Yard" coal. Llynvi Coal and Iron Company, Bridgend, Glamorganshire. Analysed by W. J. Ward.

Carbon - - - -	86·67
Hydrogen - - - -	4·77
Oxygen and Nitrogen - - -	4·30
Sulphur - - - -	0·88

Ash - - - - -	2·63
Water - - - - -	0·75
	100·00

See Percy's Metallurgy, Fuel, p. 334. A banded small splintering coal, yielding 76·86 per cent. of coke.

110. "Victoria" coal. Llynvi Coal and Iron Company, Bridgend, Glamorganshire. Analysed by W. J. Ward.

Carbon - - - -	86·59
Hydrogen - - - -	4·98
Oxygen and Nitrogen - - -	4·52
Sulphur - - - -	0·93
Ash - - - - -	2·00
Water - - - - -	0·98
	100·00

See Percy's Metallurgy, Fuel, p. 334. A broad banded, small splintering coal, yielding 73·16 per cent. of coke.

111. Top and bottom coal. No. 2 vein, Dunraven Colliery, Pontypridd, Glamorganshire. Analysed by W. J. Ward. The average of the two portions gives—

Carbon - - - -	86·81
Hydrogen - - - -	4·51
Oxygen and Nitrogen - - -	2·75
Sulphur - - - -	1·75
Ash - - - - -	3·40
Water - - - - -	0·78
	100·00

See Percy's Metallurgy, Fuel, p. 334. A small splintering coal, yielding 86·81 per cent. of coke.

112. "Imperial Merthyr" coal. Aberdare, Glamorganshire. Analysed by W. J. Ward.

Carbon - - - -	88·34
Hydrogen - - - -	4·06
Oxygen and Nitrogen - - -	3·18
Sulphur - - - -	4·66
Ash - - - - -	2·93
Water - - - - -	0·83
	100·00

See Percy's Metallurgy, Fuel, p. 334. A bright, splintering coal, yielding 87·54 per cent. of coke. Communicated by Livingston, Richards, and Almonds.

113. "Cory's Merthyr" coal. Aberdare, Glamorganshire. Analysed by W. J. Ward.

Carbon	86·80
Hydrogen	4·25
Oxygen and Nitrogen	3·06
Sulphur	0·83
Ash	4·40
Water	0·66
	100·00

See Percy's Metallurgy, Fuel, p. 334. A thin banded, splintering coal, yielding 84·42 per cent. of coke.

114. "Nine foot" coal. Bute pit, Hirvain, Aberdare, Glamorganshire. Analysed by W. J. Ward.

Carbon	90·41
Hydrogen	3·97
Oxygen and Nitrogen	2·20
Sulphur	0·78
Ash	1·95
Water	0·89
	100·00

See Percy's Metallurgy, Fuel, p. 334. A semi-anthracitic, thin splintering, non-caking coal. Its particles slightly rounded on heating. Communicated by A. Tyler.

115. Top and bottom coal. No. 2 vein. Rhondda Waterfall Colliery, Glyn Neath, Glamorganshire. Analysed by W. J. Ward. The average of the two portions gives—

Carbon	84·17
Hydrogen	4·12
Oxygen and Nitrogen	2·36
Sulphur	2·19
Ash	6·37
Water	0·79
	100·00

See Percy's Metallurgy, Fuel, p. 334. A bright thick banded coal, yielding 84·04 per cent. of coke.

116. "Nine foot" coal. Venallt Colliery, Glynabont, Neath, Glamorganshire. Analysed by W. J. Ward.

Carbon	89·26
Hydrogen	3·75
Oxygen and Nitrogen	3·25
Sulphur	0·74
Ash	1·43
Water	1·57
	100·00

See Percy's Metallurgy, Fuel, p. 334. Yields 90·86 per cent. of coke. Communicated by W. Gregory, 1871.

117. Venalt coal, No. 1. Glynabont, Neath, Glamorganshire. Analysed by W. J. Ward.

Carbon - - - -	88·85
Hydrogen - - - -	4·22
Oxygen and Nitrogen - - -	3·15
Sulphur - - - -	1·30
Ash - - - - -	1·77
Water - - - - -	0·71
	100·00

See Percy's Metallurgy, Fuel, p. 334. A dull coal, yielding 87·20 per cent. of coke. Communicated by W. Gregory, 1871.

118. Venallt coal, No. 2. Glynabont, Neath, Glamorganshire. Analysed by W. J. Ward.

Carbon - - - -	85·00
Hydrogen - - - -	3·93
Oxygen and Nitrogen - - -	2·24
Sulphur - - - -	2·18
Ash - - - - -	5·85
Water - - - - -	0·80
	100·00

See Percy's Metallurgy, Fuel, p. 334. A dull, banded coal, yielding 87·74 per cent. of coke.

119. "Wain-y-Coed" coal. Pontardawe, Swansea, Glamorganshire. Analysed by W. J. Ward.

Carbon - - - -	89·92
Hydrogen - - - -	4·32
Oxygen and Nitrogen - - -	2·37
Sulphur - - - -	0·78
Ash (red) - - - -	1·90
Water - - - - -	0·71
	100·00

See Percy's Metallurgy, Fuel, p. 335. A thin splintering coal, yielding 86·04 per cent. of coke. Communicated by the Primrose Coal Company, 1870.

120. "Primrose" coal from the Primrose Colliery, Pontardawe, Swansea, Glamorganshire. Analysed by W. J. Ward.

Carbon - - - -	88·83
Hydrogen - - - -	4·25
Oxygen and Nitrogen - - -	2·41
Sulphur - - - -	0·77

Ash (red)	3·13
Water	0·61
	100·00

See Percy's Metallurgy, Fuel, p. 335. A thin splintering coal, yielding 83·82 per cent. of coke. Communicated by the Primrose Coal Company, 1870.

121. No. 3 coal. Nant-y-Moel Colliery, Ogmore Valley, Glamorganshire. Analysed by W. J. Ward. Used at the Tonddu Ironworks.

Carbon	86·67
Hydrogen	5·03
Oxygen and Nitrogen	4·44
Sulphur	1·15
Ash	1·63
Water	1·08
	100·00

See Percy's Metallurgy, Fuel, p. 335. In small fragments. Yields 71·70 per cent. of coke.

122. Anthracite from Landshipping Colliery, Haverfordwest, Pembrokeshire. Analysed by W. J. Ward.

	As sent.	Dried at 212° F.
Carbon	91·05	92·35
Hydrogen	2·80	2·85
Oxygen and Nitrogen	1·72	1·74
Sulphur	0·98	0·99
Ash (light red)	2·05	2·07
Water	1·40	—
	100·00	100·00

See Percy's Metallurgy, Fuel, p. 335. A brilliant, compact, broad-banded, non-caking coal.

123. "Upper four foot seam." Blaen Rhondda Colliery, Glamorganshire. Analysed by W. J. Ward.

Carbon	86·49
Hydrogen	3·69
Oxygen and Nitrogen	3·08
Sulphur	0·91
Ash	4·75
Water	1·08
	100·00

See Percy's Metallurgy, Fuel, p. 335. A dull, small splintering, non-caking coal.

124. Hafod coal. Glamorganshire. Analysed by W. J. Ward.

Carbon - - - -	86·95
Hydrogen - - - -	4·84
Oxygen and Nitrogen - - -	4·64
Sulphur - - - -	0·64
Ash - - - - -	2·05
Water - - - -	0·88
	100·00

See Percy's Metallurgy, Fuel, p. 335. A bright, brittle coal, yielding 76·87 per cent. of coke.

125. Anthracite. Capel Ifan Colliery, Caermarthenshire. Analysed by W. J. Ward after desiccation.

Carbon - - - -	92·19
Hydrogen - - - -	3·24
Oxygen and Nitrogen - - -	1·57
Sulphur - - - -	1·07
Ash - - - - -	1·93
	100·00

See Percy's Metallurgy, Fuel, p. 569, where the analysis includes 1·25 per cent. of water. A brilliant and compact coal. Total volatile matter 6·05 per cent. Communicated by A. C. Miller.

126. Anthracite suitable for malting. From the Deep Stanllyd Big Vein, Llandebie, Caermarthenshire.

A bright compact coal.

127. Anthracite from the "Pump Quart" Vein, Llandebie, Caermarthenshire.

A bright and somewhat brittle, pyritous coal, containing "Mother of coal."

128. Anthracite from the "Pump Quart" Vein, Llandebie, Caermarthenshire.

A very bright and compact coal, free from "Mother of coal."

129. Anthracite from Llangennech Colliery, Llanelly, Glamorganshire. A steam coal. Analysed by W. J. Ward.

Carbon - - - -	86·32
Hydrogen - - - -	3·09
Oxygen and Nitrogen - - -	4.29
Sulphur - - - -	0·66
Ash (pale red) - - - -	4·77
Water - - - - -	0·87
	100·00

See Percy's Metallurgy, Fuel, p. 569. A dull fibrous coal, yielding 85·08 per cent. of firm lustrous coke.

130. "Grey Gog" seam. Trimsaran Colliery, Kidwelly, Caermarthenshire, without band. Analysed by W. J. Ward.

Carbon - - - -	85·86
Hydrogen - - - -	3·51
Oxygen and Nitrogen - - -	2·47
Sulphur - - - -	0·80
Ash (white) - - - -	5·87
Water - - - - -	1·49
	100·00

See Percy's Metallurgy, Fuel, p. 570. A bright, small splintering anthracite, yielding 91·88 per cent. of coke.

131. The "Green" seam. Trimsaran Colliery, Kidwelly, Caermarthenshire. Analysed by W. J. Ward.

Carbon - - - -	90·53
Hydrogen - - - -	3·61
Oxygen and Nitrogen - - -	1·89
Sulphur - - - -	1·07
Ash (red) - - - -	1·30
Water - - - - -	1·60
	100·00

See Percy's Metallurgy, Fuel, p. 570. A bright, small splintering anthracite, yielding 90·90 per cent. of coke.

132. The "Drap Vein" top coal. Trimsaran Colliery, near Kidwelly, Caermarthenshire.

An earthy coal, with transverse fibration due to pressure.

133. The "Drap Vein" bottom coal. Trimsaran Colliery, near Kidwelly, Caermarthenshire.

An irregular thin-banded coal.

134. "Smokeless steam coal" from Trimsaran Collieries, near Kidwelly, Caermarthenshire. Composed of equal parts by weight of two seams. Analysed in bulk by W. J. Ward after desiccation.

Carbon - - - -	90·51
Hydrogen - - - -	3·85
Oxygen and Nitrogen - - -	2·30
Sulphur - - - -	0·80
Ash (red) - - - -	2·54
	100·00

Both are bright, small splintering coals.

135. Rhondda coal. Pwllfaron Colliery, Glyn Neath, Glamorganshire. Analysed by W. J. Ward.

Carbon - - - -	88·25
Hydrogen - - - -	3·71
Oxygen and Nitrogen - - -	2·09
Sulphur - - - -	0·84
Ash (dark greyish red) - -	4·13
Water - - - - -	0·98
	100·00

See Percy's Metallurgy, Fuel, p. 569. An anthracite in small dull pieces, yielding 92·59 per cent. of coke.

136. "Duffryn" coal. Dynevor, Duffryn Colliery, Neath, Glamorganshire.

A dull irregularly banded coal.

137. "No. 2 Rhondda" coal. Top portion. Glyn Corrwg Colliery, Cardiff. Analysed by W. J. Ward.

Carbon - - - -	86·71
Hydrogen - - - -	4·71
Oxygen and Nitrogen - - -	3·20
Sulphur - - - -	1·53
Ash (pink) - - - -	3·06
Water - - - - -	0·79
	100·00

See Percy's Metallurgy, Fuel, p. 569. A thin-banded, decaying coal, yielding 80·72 per cent. of coke in concentric layers.

138. "No. 2 Rhondda" coal. Middle portion. Glyn Corrwg Colliery, Cardiff. Analysed by W. J. Ward.

Carbon - - - -	83·99
Hydrogen - - - -	4·42
Oxygen and Nitrogen - - -	2·42
Sulphur - - - -	2·69
Ash (red) - - - -	5·75
Water - - - -	0·73
	100·00

See Percy's Metallurgy, Fuel, p. 569. A dull coal, mostly decayed to powder, yielding 81·08 per cent. of coke in concentric layers.

139. "No. 2 Rhondda" coal. Bottom portion. Glyn Corrwg Colliery, Cardiff. Analysed by W. J. Ward.

Carbon - - -	84·99
Hydrogen - - - -	4·39
Oxygen and Nitrogen - - -	3·70

Sulphur - - - -	1·49
Ash (pink) - - - -	4·83
Water - - - - -	0·60
	100·00

See Percy's Metallurgy, Fuel, p. 569. A moderately bright, small splintering coal, yielding 80·52 per cent. of coke in concentric layers.

140. "Six feet" or top coal. Great Western Colliery, Pontypridd, Glamorganshire.

A dull, thin splintering coal.

141. "Four feet" or middle coal. Great Western Colliery, Pontypridd, Glamorganshire.

A moderately bright, brittle coal.

142. "Four feet" coal. Cymmer Colliery, Porth, Glamorganshire.

A bright coal.

143. "Nine feet" coal. Cymmer Colliery, Porth, Glamorganshire.

A rather dull coal.

144. "No. 2 Rhondda" coal. Corrwg Fechan Colliery, Glyn Corrwg, Cardiff.

A rather dull, splintery coal.

145. Anthracite from the upper part of Penygraig vein, No. 2 Rhondda. Penygraig Colliery, Cwm Click, near Pontypridd, Glamorganshire. Analysed by W. J. Ward.

Carbon - - - -	85·79
Hydrogen - - - -	3·71
Oxygen and Nitrogen - - -	2·17
Sulphur - - - -	1·89
Ash (reddish grey) - - -	5·25
Water - - - -	1·19
	100·00

See Percy's Metallurgy, Fuel, p. 570. Broken down to small fragments.

146. Anthracite from the lower part of Welsh vein, No. 3 Rhondda. Penygraig Colliery, Cwm Click, near Pontypridd, Glamorganshire. Analysed by W. J. Ward.

Carbon - - - -	86·14
Hydrogen - - - -	3·40
Oxygen and Nitrogen - - -	2·39
Sulphur - - - -	1·83
Ash (pale red) - - - -	4·42
Water - - - - -	1·82
	100·00

See Percy's Metallurgy, Fuel, p. 570. Breaks into small, dull pieces.

147. Anthracite from the lower seam. Bonville Court Colliery, Saundersfoot, Pembrokeshire.

A bright, compact coal, with conchoidal fracture.

148. Anthracite from the same locality as No. **147.**

A bright, banded coal showing iridescent colours.

149. "Kilgetty" coal. Kilgetty Colliery, Saundersfoot, Pembrokeshire.

A brilliant banded coal.

150. Anthracite from Moreton Colliery, Saundersfoot, near Tenby, Pembrokeshire.

A bright banded coal.

151. The "six foot" seam. Mynydd-Bach-y-glo Colliery, Swansea, Glamorganshire.

A dull and fibrous coal, used for household purposes, gas-making, and smelting. Communicated by W. P. Struve.

152. The "three foot" seam. Mynydd-Bach-y-glo Colliery, Swansea, Glamorganshire.

An irregular dull coal, very free from sulphur and excellent for foundry and smelting purposes. Communicated by W. P. Struve.

153. The "two foot" vein. Mynydd-Bach-y-glo Colliery, Swansea, Glamorganshire.

A dull, rather compact coal, suitable for household purposes, gas-making, and smelting. Communicated by W. P. Struve.

154. "Ynysgreinion" anthracite, smokeless steam coal, used also for malting. Victoria Coal and Iron Company, Swansea, Vale Ystalyfera, Glamorganshire. Analysed by W. J. Ward.

Carbon - - - -	89·53
Hydrogen - - - -	3·66
Oxygen and Nitrogen - - -	1·98
Sulphur - - - -	1·38
Ash (red) - - - -	1·75
Water - - - - -	1·70
	100·00

See Percy's Metallurgy, Fuel, p. 570. A very brilliant, small splintering coal, yielding 91·10 per cent. coke.

155. "Ynysgeinion" malting coal No. 2. Ystalyfera, Glamorganshire. Analysed by W. J. Ward.

Carbon	90·49
Hydrogen	3·97
Oxygen and Nitrogen	0·88
Sulphur	1·18
Ash (pale red)	2·20
Water	1·28
	100·00

A brilliant, small splintering coal.

156. "Ynyscedwin" coal No. 1. Near Swansea, Glamorganshire. Analysed by W. J. Ward.

Carbon	90·48
Hydrogen	3·77
Oxygen and Nitrogen	1·95
Sulphur	0·54
Ash (pale reddish grey)	1·95
Water	1·31
	100·00

A compact, not very brilliant coal.

157. "Ynyscedwin" coal No. 2. Near Swansea, Glamorganshire. Analysed by W. J. Ward.

Carbon	87·61
Hydrogen	3·62
Oxygen and Nitrogen	3·10
Sulphur	3·81
Ash (white)	3·55
Water	1·31
	100·00

Brilliant, thin banded, and compact.

158. "Ynyscedwin" coal No. 3. Near Swansea, Glamorganshire. Analysed by W. J. Ward.

Carbon	87·76
Hydrogen	3·76
Oxygen and Nitrogen	2·75
Sulphur	0·78
Ash (pale, reddish grey)	3·70
Water	1·25
	100·00

Brilliant, banded, and compact.

159. "Ynyscedwin" coal No. 4. Near Swansea, Glamorganshire. Analysed by W. J. Ward.

Carbon - - - -	86·67
Hydrogen - - - -	3·24
Oxygen and Nitrogen - - -	3·15
Sulphur - - - -	0·74
Ash (pale, reddish grey) - -	5·00
Water - - - - -	1·20
	100·00

A compact and dull coal.

160. "Four feet" seam. Maedy Colliery, Pontypridd, Glamorganshire.

A steam coal. Not very bright, but banded. Communicated by E. S. Judkins.

161. Coals No. 1 and 2 from Glamorgan Colliery, Pontypridd, Glamorganshire.

Both are bright and banded.

162. Coals No. 3 and 4 from Glamorgan Colliery, Pontypridd, Glamorganshire.

Bright and thin splintering.

163. Coals No. 5 and 6 from Glamorgan Colliery, Pontypridd, Glamorganshire.

One is dull, the other brighter.

164. "Black vein" steam coal. Celynen Colliery, Abercarn, Monmouthshire.

A bright, thin banded coal.

165. Tyrcenol coal. Used in copper smelting at Hafod Works, near Swansea. Mixed with equal parts of Mynydd Newydd and Pentrefelin coals. Analysed by A. Dick after desiccation.

Carbon - - - -	76·81
Hydrogen - - - -	3·42
Oxygen and Nitrogen - - -	5·65
Sulphur - - - -	1·96
Ash - - - - -	12·16
	100·00

See Percy's Metallurgy, Fuel, p. 350, where analyses of the ashes of these coals are also given. In fragments.

166. "Top Coal." Henlis Coal and Firebrick Works, Newport, Monmouthshire. Analysed by W. J. Ward.

Carbon - - - -	75·85
Hydrogen - - - -	4·74
Oxygen and Nitrogen - - -	7·72
Sulphur - - - -	1·09
Ash (grey) - - - -	8·87
Water - - - - -	1·73
	100·00

See Percy's Metallurgy, Fuel, p. 570. Yields 69·40 per cent. of coke. Communicated by J. C. Hill, 1874.

167. "Bottom coal." Henlis Coal and Firebrick Works, Newport, Monmouthshire. Analysed by W. J. Ward.

Carbon - - - -	74·90
Hydrogen - - - -	4·98
Oxygen and Nitrogen - - -	8·16
Sulphur - - - -	1·69
Ash (reddish grey) - - -	8·17
Water - - - - -	2·10
	100·00

See Percy's Metallurgy, Fuel, p. 570. Yields 65·60 per cent. of coke. Communicated by J. C. Hill, 1874.

168. "Smith coal," or 20-inch coal, Forest of Dean.

Nearly the highest seam in the district. Bright and compact.

169. "Little Delf," Forest of Dean; average thickness 20 in.

Follows the Smith coal. Less compact and duller.

170. "Parkend High Delf," or "Lowry" coal, Forest of Dean; average thickness 3 ft. 7 in.

Follows the Little Delf. The only sort used at Parkend furnaces. Brilliant and compact.

171. Black shale. Parkend, High Delf Colliery, Forest of Dean. Analysed by C. Tookey.

In small fragments.

172. "Starkey Delf," Forest of Dean; average thickness 2 ft.

Follows the Parkend. Duller, compact, and thin banded.

173. "Rocky Delf," Forest of Dean; average thickness 1 ft. 2in.

Follows the Starkey. Compact, banded, alternately bright and dull.

174. "Churchway High Delf," or "Oaken Hill and Smart Delf," Forest of Dean; average thickness 1 ft. 11 in.

Follows the Rocky, and is followed by Churchway Low Delf. Rather dull, compact.

175. Bailey or Yorkley Delf, Forest of Dean; average thickness 1 ft. 9 in.

Follows the Churchway Delf, and is followed by Nags Head Delf. Thin banded, efflorescing and decayed.

176. "Whittington," Forest of Dean; average thickness 2 ft. 6 in.

Follows the Nags Head Delf. An earthy coal, very brown and resinous looking.

177. "Coleford High Delf," Forest of Dean; average thickness 5 ft.

Follows the Whittington. Not very bright nor compact.

178. "Trenchard Coal," Forest of Dean; averages 2 ft.

Follows the Coleford High Delf, and is the lowest coal but one in the field. Dull, earthy, effloresced, and decayed.

179. "Top coal," Bagworth, Leicester.

Dull and earthy, like cannel. Communicated by the Glyndon Iron Company, 1871.

180. "Middle coal," Bagworth, Leicester.

Very dull, thin banded, and compact. Communicated by the Glyndon Iron Company, 1871.

181. "Main coal," Whitwick Colliery, Leicester. Analysed by J. W. Ward, 1875.

Carbon - - - -	69·00
Hydrogen - - - -	4·35
Oxygen and Nitrogen - - -	10·78
Sulphur - - - -	0·78
Ash (pinkish) - - - -	5·42
Water - - - - -	9·67
	100·00

See Percy's Metallurgy, Fuel, p. 570. Yields 58·14 per cent. of coke and 32·19 per cent. of volatile matter.

182. Coal from the Leeswood Green Colliery, Mold, Flintshire, showing "mother of coal."

Very bright and compact, the mother of coal being the disintegrated parting between the solid layers.

183. "Arley Mine coal," Wigan, Lancashire; considered the best coal in the district for house, gas, and coking purposes.

Compact, iridescent, and slightly effloresced.

184. "Arley Mine coal," Wigan, Lancashire; of a different structure from No. **187**, and from a different part of the workings.

Duller and more thinly banded.

185. Wigan cannel coal, in association with ordinary coal, which takes its place as the cannel dies away, so that the average total thickness is maintained.

Communicated by C. Wright.

186. The ordinary Wigan coal, that accompanies the cannel coal, without any of the latter.

A dull, very compact coal. Communicated by C. Wright.

187. "Thick" coal, or 6 ft. seam, Burnley Coalfield, from Bancroft Colliery, Padiham, Lancashire.

A broad-banded, moderately bright coal. Communicated by Sir J. K. Shuttleworth.

188. "Roof coal," Gawthorpe Colliery, in the Burnley Coal field, Lancashire.

Rather dull and more thinly banded. Communicated by Sir J. K. Shuttleworth.

189. "Low Moor" coal; hard; Yorkshire.

Very dull, compact, and thin banded.

190. "Low Moor" coal; soft; Yorkshire.

Bright, with thin bands alternately bright and dull.

191. Iron pyrites in soft Low Moor coal.

192. "Hesley Silkstone" coal, near Barnsley, Yorkshire.

Compact, thin banded, rather dull. Communicated by Newton, Chambers, and Co.

193. "Silkstone Gas" coal, near Barnsley, Yorkshire.

Brighter and more thickly banded. Communicated by Newton, Chambers, and Co.

194. Steam coal, from near Barnsley, Yorkshire.

Bright and moderately thin banded. Communicated by Newton, Chambers, and Co.

195. "Yorkshire coal," sample A. Analysed by W. J. Ward.

Carbon	72·31
Hydrogen	5·52
Oxygen and Nitrogen	9·62
Sulphur	2·44
Ash (reddish grey)	4·80
Water	5·31
	100·00

A very bright and compact coal, with a uniform, almost conchoidal fracture, and yielding 56·32 per cent. of coke. Communicated by Row. Winn.

196. "Yorkshire coal," sample B. Analysed by W. J. Ward.

Carbon	74·05
Hydrogen	5·25
Oxygen and Nitrogen	10·38
Sulphur	1·66
Ash (reddish grey)	2·64
Water	6·02
	100·00

Similar to the last, but the fracture is a little rougher. Yields 56·92 per cent. of coke. Communicated by Row. Winn.

197. Coal from Fair Oak Colliery.

Rather dull and irregularly banded.

198. "Fernhill" coal.

Very bright and broad banded, with dull partings.

199. Sample from a mass of coal which ignited spontaneously in the Woolwich Gasworks in 1873.

It was received as "New Pelton Gas Coal," and in a wet condition 150 tons of it were stored in a shed having only the front open; and 2,000 tons of other coal were placed on the top, and no system of internal ventilation was adopted. It ignited after six months' storage, from May to November. This is not, properly speaking, a coal at all, but a mass of pyrites in which is imbedded a large quantity of the charcoal-like mother of coal. Communicated by C. Iceby.

200. "Six-foot" coal from Pentrefelin Colliery, near Swansea, Glamorganshire.

Used in the Copper Smelting Works at Hafod. Mixed with equal parts of Mynydd Newydd and Tyrcenol coal. Analysed by A. Dick after desiccation.

Carbon	78·49
Hydrogen	3·73
Oxygen and Nitrogen	4·15
Sulphur	2·56
Ash	11·07
	100·00

See Percy's Metallurgy, Fuel, p. 350. Moderately light and broad banded.

201. "Six-foot coal" from Mynydd Newydd Colliery, near Swansea, Glamorganshire.

Used in copper smelting works at Hafod. Mixed with equal parts of Pentrefelin and Tyrcenol. Analysed by A. Dick after desiccation.

Carbon - - - -	73·87
Hydrogen - - - -	3·73
Oxygen and Nitrogen - - -	8·02
Sulphur - - - -	1·55
Ash - - - - -	12·83
	100·00

See Percy's Metallurgy, Fuel, p. 350. Rather dull and small splintering.

202. Coal of the age of the Lower Oolites from the Brora Coalfield, Sutherlandshire. (*See* Hull's Coalfields of Great Britain.)

A perfectly black and compact coal, brighter than cannel coal. Communicated by the Duke of Sutherland.

FOREIGN COALS.

EUROPEAN COALS.

203. Coal from Steyerdorf, Switzerland. Of Carboniferous age.

Formerly supposed to belong to the Lias, having been misplaced by the inversion of the strata. Small fractured, solid, feebly banded.

204. Coal from the level at Courtres (Novelle ?), Switzerland. Of Carboniferous age. Analysed by W. J. Ward.

Carbon - - - -	59·16
Hydrogen - - - -	3·78
Oxygen and Nitrogen - - -	4·97
Sulphur - - - -	3·48
Ash (pale red) - - - -	28·13
Water - - - - -	·48
	100·00

See Percy's Metallurgy, Fuel, p. 336. Compact, dull, without banding and with irregular fracture. Yields a light coke. Communicated by McDougal Smith, 1865.

205. Coal from the upper or east gallery, Novelle, Switzerland. Of Carboniferous age.

A dark earthy lignite-like coal with irregular fracture. Yields 45·40 per cent. of a scarcely coherent coke and 10·95 per cent. of ash. Burns with a smoky yellow flame. Communicated by McDougal Smith, 1865.

206. Coal from Novelle, Switzerland. Of Carboniferous age.

Yields 55·28 per cent. of coke and 2·70 of ash. Burns with a smoky flame and yields much gas, and decrepitates. Brilliant, compact, and resinous, with conchoidal fracture. Communicated by McDougal Smith, 1865.

207. Coal from Servia.

A very dark irregular lignite.

208. Cannel coal from Styria.

A hard earthy black shale. Used in the manufacture of gas at Vienna by the Imperial and Continental Gas Company. Communicated by E. W. Voelcher, 1876.

AMERICAN COALS.

209. Coal from Springfield, Bay of Fundy, Nova Scotia. Of Carboniferous age. Analysed by W. J. Ward.

Carbon - - - -	75·51
Hydrogen - - - -	5·00
Oxygen and Nitrogen - - -	9·37
Sulphur - - - -	1·09
Ash (greyish white) - - -	5·05
Water - - - - -	3·98
	100·00

See Percy's Metallurgy, Fuel, p. 337. A dull, resinous looking coal with irregular fracture. Yields 64·94 per cent. of coke. Communicated by J. Livesey.

210. Glasgow and Cape Breton coal, Nova Scotia; of Carboniferous age. Analysed by W. J. Ward.

Carbon - - - -	77·41
Hydrogen - - - -	5·47
Oxygen and Nitrogen - - -	9·30
Sulphur - - - -	2·47
Ash (dark greyish red) - -	4·35
Water - - - - -	1·00
	100·00

Dull and compact in one part, decayed in another; yields 62·74 per cent. of coke and 36·20 of volatile matter. Communicated by the Glasgow and Cape Breton Coal Company.

211. Coal from Schooner Pond, Nova Scotia; of Carboniferous age. Analysed by W. J. Ward.

Carbon - - - -	78·10
Hydrogen - - - -	5·48
Oxygen and Nitrogen - - -	7·81
Sulphur - - - -	2·49
Ash (dark greyish red) - -	3·45
Water - - - - -	2·67
	100·00

It has an irregular fracture, and is effloresced and disintegrated. It yields 61·90 per cent. of coke and 35·43 per cent. of volatile matter. Communicated by the Glasgow and Cape Breton Coal Company.

212. Cannel coal from Schooner Pond, Nova Scotia; of Carboniferous age. Analysed by W. J. Ward.

Carbon - - - -	63·72
Hydrogen - - - -	4·79
Oxygen and Nitrogen - - -	3·94
Sulphur - - - -	6·35
Ash (red) - - - -	19·95
Water - - - - -	1·25
	100·00

See Percy's Metallurgy, Fuel, p. 337. A dull, massive coal, like cannel, yielding 63·11 per cent. of a hard and compact coke, and 35·64 per cent. of volatile matter. Communicated by the Schooner Pond Coal Company.

213. Coal from the Inter-colonial Company's Colliery, Pictou County, Nova Scotia. Of Carboniferous age.

The seam called the "Lower Bunch," which is about 19 feet thick. A rather dull, compact, thin-banded coal.

214. Coal from the Inter-colonial Company's Colliery, Pictou County, Nova Scotia. Of Carboniferous age.

The seam called "Upper Bunch," which is about 19 feet thick. A compact and thin-banded coal.

215. Coal from the Albion Mines, Pictou County, Nova Scotia. From the "Cage pit." Of Carboniferous age.

The "Deep seam," 12 feet thick, yielding a good coal in three bands. It is dull and compact, with narrow bright bands.

216. Coal from the Albion Mines, Pictou County, Nova Scotia. Of Carboniferous age.

The "Main seam," 38 feet thick, with some partings, also called the "Upper Bunch." A dull, thin-banded coal, with much "mother of coal."

217. Coal from "Mitchells adit," Pictou County, Nova Scotia. Of Carboniferous age.

About 13 feet thick with some coarse coal. Bright, irregularly banded.

218. Coal from the Vale Colliery, Pictou County, Nova Scotia. Of Carboniferous age.

The "Eight-foot" seam. Dull, thin-banded.

219. Coal from Vale Colliery, Pictou County, Nova Scotia.

The outcrop of the 3-foot seam. Communicated by G. M. Dawson.

220. The Coal, Brick, and Pottery Company's seam, Pictou County, Nova Scotia. Of Carboniferous age.

A coal 2 feet thick, worked with several feet of fire-clay. Irregularly banded, alternately dull and bright.

221. Coal from "Chimney corner," Cape Breton Island. Of Carboniferous age.

Broad banded, with no bright layers and some very dusty.

222. Coal from Port Hood, Cape Breton Island. The main or "six foot" seam. Of Carboniferous age.

Compact and thin-banded, but now completely effloresced and fragmentary.

223. Coal from the Vancouvers Coal Mines and Land Company's Colliery, Vancouvers Island, British Columbia. Of Cretaceous age. Analysed by W. J. Ward.

Carbon	72·29
Hydrogen	5·58
Oxygen and Nitrogen	6·36
Sulphur	2·62
Ash	11·62
Water	1·53
	100·00

See Percy's Metallurgy, Fuel, p. 338. A black, dull, not clearly banded coal, in small pieces, yielding 57·15 per cent. of coke.

224. Coal from Vancouvers Coal Mines and Land Company's Colliery, Vancouvers Island, British Columbia. Of Cretaceous age. Analysed by W. J. Ward.

Carbon	69·93
Hydrogen	4·95
Oxygen and Nitrogen	11·48
Sulphur	0·74
Ash	9·70
Water	3·20
	100·00

See Percy's Metallurgy, Fuel, p. 338. A rather dull, broad-banded, black coal, yielding 60·08 per cent. of coke. Communicated by Mr. Robins, 1873.

225. Coal from Vancouvers Coal Mines and Land Company's Colliery, Vancouvers Island, British Columbia. Of Cretaceous age. Analysed by W. J. Ward.

Carbon	70·99
Hydrogen	5·19
Oxygen and Nitrogen	10·20
Sulphur	0·97
Ash	9·75
Water	2·90
	100·00

See Percy's Metallurgy, Fuel, p. 338. A rather dull, irregularly breaking, not clearly banded coal, yielding 62·15 per cent. of coke. Communicated by Mr. Robins, 1873.

226. Coal from near Nanaimo, Vancouvers Island, British Columbia. Of Cretaceous age. Analysed by W. J. Ward.

Carbon - - - -	73·28
Hydrogen - - - -	5·37
Oxygen and Nitrogen - - -	11·44
Sulphur - - - -	0·51
Ash (dirty buff) - - -	6·63
Water - - - - -	2·77
	100·00

See Percy's Metallurgy, Fuel, p. 338. A black, moderately bright and compact, rather broad-banded coal, yielding 58·80 per cent. of coke and 38·43 per cent. of volatile matter. Communicated by the Admiralty.

227. Coal brought to England by H.M.S. "Discovery," discovered during the Arctic expedition in 1876. It occurs in 81° 43′ N. L. and 64° 4′ W. L. It is of Miocene age. A sample analysed by R. J. Moss yielded—

Carbon - - - -	75·49
Hydrogen - - - -	5·60
Oxygen and Nitrogen - - -	9·89
Sulphur - - - -	0·52
Ash - - - - -	6·49
Water - - - - -	2·01
	100·00

A black, lustrous, tender coal, in thin bands and with many transverse cracks. Yields 61 per cent. of coke. *See* Proc. Royal Dublin Society, N.S., vol. 1, p. 61.

228. "Black Diamond" or "Tower Vein" from Mount Diablo. About 40 miles South of San Francisco, California.

A compact cannel-like coal, slightly banded. Communicated by J. Jouberton.

229. Colorado coal; locality not stated.

Dull, almost resinous, thin-banded. Communicated by W. Cope.

230. Coal from Cañon City on the Arkansas river in Colorado, North America. Probably of Cretaceous age.

A compact bright coal, indistinctly but thinly banded. Communicated by A. G. Renshaw, 1874.

231. Coal from the United States of Colombia, South America. Analysed by W. J. Ward.

Carbon	76·45
Hydrogen	4·88
Oxygen and Nitrogen	12·06
Sulphur	0·25
Ash	1·25
Water	5·11
	100·00

See Percy's Metallurgy, Fuel, p. 339. A dull, very tender, thin-banded, non-caking coal. Communicated by the Admiralty, 1872.

232. Coal from the United States of Colombia. Analysed by W. J. Ward.

Carbon	56·66
Hydrogen	4·08
Oxygen and Nitrogen	17·25
Sulphur	0·30
Ash	2·63
Water	19·08
	100·00

See Percy's Metallurgy, Fuel, p. 339. A very dull and tender black coal, in separate layers of compacted dust. Communicated by the Admiralty, 1872.

233. Coal from San Jeronymo, New Granada. Analysed by C. Tookey.

Carbon	59·05
Hydrogen	4·03
Oxygen and Nitrogen	10·54
Sulphur	0·54
Ash (nearly white)	16·68
Water	9·16
	100·00

See Percy's Metallurgy, Fuel, p. 340. A tolerably compact and thin banded coal.

234. Coal from Brazil. Analysed by W. J. Ward.

Carbon	56·28
Hydrogen	3·87
Oxygen and Nitrogen	10·74
Sulphur	0·56
Ash (white)	16·85
Water	11·70
	100·00

See Percy's Metallurgy, Fuel, p. 340. A very dull and compact coal, yielding 59·60 per cent. of coke. It has occasional bright bands and splits along the bedding. Its composition is the same as some South Staffordshire coals.

235. Coal from the Province of S. Catherine's, Brazil.

A dull, brownish black, compact coal, with irregular bright bands.

236. Coal from the Imperial Brazilian Collieries Company's mines, South Brazil.

A dull, compact, banded coal, with occasional bright bands.

237. Coal from Punta Arenas or Sandy Point, Straits of Magellan. Analysed by W. J. Ward.

Carbon - - - -	74·82
Hydrogen - - - -	4·91
Oxygen and Nitrogen - - -	8·93
Sulphur - - - -	0·82
Ash - - - - -	6·98
Water - - - - -	3·54
	100·00

See Percy's Metallurgy, Fuel, p. 341. A compact, dull, very feebly broad-banded coal, yielding 62·80 per cent. of compact coke. Communicated by the Admiralty, 1873.

238. Coal from Chili, near Coronel, 250 miles south of Valparaiso. Analysed by W. J. Ward.

Carbon - - - -	69·87
Hydrogen - - - -	5·51
Oxygen and Nitrogen - - -	9·73
Sulphur - - - -	1·00
Ash - - - - -	10·07
Water - - - - -	3·82
	100·00

See Percy's Metallurgy, Fuel, p. 341. A bright, compact, feebly banded coal, yielding 60·56 per cent. of compact coke.

239. Coal from the South of Chili.

Used for smelting copper, for which purpose it is mixed with two-thirds of its weight of Welsh coal. A dull coal, once compact, now effloresced and decayed. Communicated by the Copiapo Smelting Company, Caldera.

240. Anthracite from Peru. Brought by H. Bauerman from a 6 ft. bed at Poaten, in the Pampas of the Sierra, 40 miles north-east of Truxillo. Believed to be of Mesozoic age. Analysed by W. J. Ward.

Carbon - - - -	82·70
Hydrogen - - - -	1·41
Oxygen and Nitrogen - - -	0·85

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Sulphur - - - -	10·55
Ash - - - - -	3·75
Water - - - - -	0·74
	100·00

See Percy's Metallurgy, Fuel, p. 567. Brilliant, compact, with irregular fracture. A sample accompanies the raw coal which has been heated for a long time; by this treatment the per-centage of sulphur was only reduced to 7·35 per cent., showing that this amount must exist in an organic combination.

Asiatic Coals.

241. Labuan coal from the north-west of Borneo. Contains small lumps of resin. Analysed by C. Tookey.

Carbon - - - -	71·66
Hydrogen - - - -	5·53
Oxygen and Nitrogen - - -	14·66
Sulphur - - - -	0·40
Ash - - - - -	1·95
Water - - - - -	5·80
	100·00

See Percy's Metallurgy, Fuel, p. 342. A bright, compact coal, with irregular fracture and obscure bands, yielding 50·70 per cent. of semi-coherent coke. Communicated by Vice-Admiral Hope, 1872.

242. Labuan coal. Labuan Coal Company, Borneo. Analysed by C. Tookey.

Carbon - - - -	72·27
Hydrogen - - - -	5·20
Oxygen and Nitrogen - - -	14·28
Sulphur - - - -	0·30
Ash - - - - -	1·85
Water - - - - -	6·10
	100·00

See Percy's Metallurgy, Fuel, p. 342. A very compact, bright coal, with conchoidal fracture, resembling cannel coal, and having no banding. Yields 56·10 of coke. Communicated by Vice-Admiral Hope, 1872.

243. Labuan coal. Analysed by W. J. Ward, 1865.

Carbon - - - -	70·96
Hydrogen - - - -	5·57
Oxygen and Nitrogen - - -	14·34
Sulphur - - - -	1·43
Ash (pale red) - - -	2·15
	100·00

See Percy's Metallurgy, Fuel, p. 342. A dull, compact, thinly and obscurely banded coal, yielding 52·16 per cent. of coke.

244. Coal from Labuan, N.W. of Borneo. Sample from the surface outcrop obtained in 1851.

Dull, resinous, banded. Communicated by J. Drummond.

245. Labuan coal. Analysed by W. J. Ward, 1865.

Carbon - - - -	71·56
Hydrogen - - - -	5·09
Oxygen and Nitrogen - - -	14·47
Sulphur - - - -	0·98
Ash (brownish red) - - -	2·45
Water - - - -	5·45
	100·00

See Percy's Metallurgy, Fuel, p. 342. Yields 51·02 per cent. of coke. It is a broad-banded, dull, effloresced coal, which contained, when received, pyrites, ferrous sulphate, and basic ferric sulphate.

246. Coal from Sumatra, called "Ranti" coal. Analysed by W. J. Ward, 1872.

Carbon - - - -	75·27
Hydrogen - - - -	5·63
Oxygen and Nitrogen - - -	12·56
Sulphur - - - -	0·49
Ash - - - - -	0·83
Water - - - -	5·22
	100·00

See Percy's Metallurgy, Fuel, p. 343. A very compact, moderately bright coal, in very broad ill-defined bands. Yields 54·58 per cent. of coke.

247. Coal from Sumatra, called "Soengei Doerian" coal. Analysed by W. J. Ward, 1872.

Carbon - - - -	73·04
Hydrogen - - - -	4·99
Oxygen and Nitrogen - - -	12·41
Sulphur - - - -	1·08
Ash - - - - -	1·43
Water - - - -	7·05
	100·00

See Percy's Metallurgy, Fuel, p. 343. A very compact, moderately bright coal, with a very obscure but excessively fine banding. Yields 55·48 per cent. of coherent coke.

248. Coal No. 1, from Tjitjalenka, Java. Analysed by W. J. Ward.

Carbon	47·91
Hydrogen	4·71
Oxygen and Nitrogen	11·31
Sulphur	0·74
Ash (buff)	23·32
Water	12·01
	100·00

A very dull, deep brown, very compact lignite, yielding 49·52 per cent. of non-coherent carbonaceous residue and 38·17 per cent. of volatile matter. Communicated by Bateman and Company, 1872.

249. Coal No. 2, from Tjitjalenka, Java. Analysed by W. J. Ward.

Carbon	53·85
Hydrogen	3·59
Oxygen and Nitrogen	11·17
Sulphur	0·91
Ash (pale red)	8·15
Water	22·33
	100·00

A brown, earthy lignite, with occasional bright bands, yielding 46·58 per cent. of a non-coherent carbonaceous residue and 31·09 per cent. of volatile matter. Communicated by Bateman and Company, 1872.

250. Coal from the Island of Formosa.

A moderately bright, irregularly banded anthracite-like coal. Communicated by the Admiralty, 1872.

251. Coal from the Bolan Pass, Beloochistan, West of India.

An earthy, dark brown lignite. Communicated by W. H. Sykes.

252. Coal from the Ranigungi Coalfield, Bengal Colliery, of Ranigungi Coal Association.

Dull, banded, compact, with a few thin bright bands; with cylinders of coke produced from its dust. Communicated by A. J. Mackay.

253. Coal from the Ranigungi Coalfield, Damuda Valley, Bengal.

Belongs to the Gondwana series of Carboniferous age, though with the type of flora which is Mesozoic in Europe. A compact, dull coal, with bright bands.

254. Coal from "Sanctoria" Coalfield, Bengal.

Probably also of Gondwana series of Carboniferous age. A bright, compact, fine-banded coal.

255. Coal from Hyderabad, Deccan, India (No. 1). Analysed by W. J. Ward.

Carbon	62·30
Hydrogen	4·73
Oxygen and Nitrogen	12·49
Sulphur	0·81
Ash	9·55
Water	9·12
	100·00

See Percy's Metallurgy, Fuel, p. 345. A tender, irregularly banded, dull coal, yielding 54·74 per cent. of non-coherent coke. Communicated by J. G. Palmer, 1872.

256. Coal from Hyderabad, Deccan, India (No. 2). Analysed by W. J. Ward.

Carbon	60·92
Hydrogen	4·17
Oxygen and Nitrogen	13·07
Sulphur	0·51
Ash	12·65
Water	8·68
	100·00

See Percy's Metallurgy, Fuel, p. 345. A very dull, banded, lignite-like coal, yielding 57·24 per cent. of non-coherent coke. Communicated by J. G. Palmer, 1872.

257. Coal from Takasima, in the island of Niphon, Japan. Analysed by W. J. Ward.

Carbon	79·26
Hydrogen	5·86
Oxygen and Nitrogen	8·76
Sulphur	0·11
Ash (pale red)	4·51
Water	1·50
	100·00

See Percy's Metallurgy, Fuel, p. 345. A friable, small splintering, not very brilliant coal, yielding 58 per cent. of tender coke.

258. Anthracite from China, locality unknown. Brought from Pekin. Analysed by C. Tookey.

Carbon	72·27
Hydrogen	2·00
Oxygen and Nitrogen	3·42
Sulphur	0·41
Ash (sandy grey)	19·00
Water	2·90
	100·00

See Percy's Metallurgy, Fuel, p. 348. A bright, compact, thin-banded coal, which does not cake in the slightest degree and gives no illuminating gas on ignition. It yields 89·55 per cent. of carbonaceous residue and 7·55 per cent. of volatile matter. Communicated by the Admiralty. Obtained by James Hope.

259. Coal from the hills about 180 miles west of Pekin near Tung-chow; believed to be of Mesozoic age. (*See* Newberry, Am. Journ. Sci. XLII.) Analysed by C. Tookey.

Carbon - - - -	85·3
Hydrogen - - - -	4·50
Oxygen and Nitrogen - - -	3·39
Sulphur - - - -	0·40
Ash (brownish red) - - -	5·82
Water - - - - -	0·53
	100·00

See Percy's Metallurgy, Fuel, p. 348. A very bright, large-fractured coal, yielding 83·47 per cent. of coke and 16·60 per cent. of volatile matter. In trial on board the "Weasel" it was found to be equal or superior to the best Welsh steam coal. Communicated by the Admiralty. Obtained by James Hope.

260. Coal from the hills near Tseng-ko-ken, in the province of Pechili, and brought from Jehol in Tartary. Analysed by C. Tookey.

Carbon - - - -	70·09
Hydrogen - - - -	4·90
Oxygen and Nitrogen - - -	8·57
Sulphur - - - -	0·77
Ash (grey) - - - -	13·82
Water - - - - -	1·85
	100·00

See Percy's Metallurgy, Fuel, p. 348. A bright, compact, thick-banded coal, yielding 63·15 per cent. of a firm coherent coke, and 35 per cent. of volatile matter containing much illuminating gas. Communicated by the Admiralty.

261. Coal from the hills near Tseng-ko-ken; being part of the same parcel as No. **260**, and having the same properties. Analysed by C. Tookey.

Carbon - - - -	61·90
Hydrogen - - - -	4·58
Oxygen and Nitrogen - - -	8·57
Sulphur - - - -	0·68
Ash (grey) - - - -	22·62
Water - - - - -	1·65
	100·00

See Percy's Metallurgy, Fuel, p. 348. A duller, and more compact coal, yielding 31·30 per cent. of volatile matter. Communicated by the Admiralty.

262. Coal from China; locality unknown. Brought by J. White. 1877.

A very dull, earthy, lignite-like coal.

263. Coal from Hu-Is'un (No. 1), China.

Brilliant, compact, and thin banded.

264. Coal from Chang-chia Hill behind Po-tu village, China.

Rather tender, thin banded, alternately bright and dull.

265. Coal from Su fêng bridge, China.

Broad banded, compact.

266. Coal from Shan-ti village, China.

Bright, compact, thin banded.

267. Coal from Hu Is'un (No. 2), China.

Bright, rather tender, irregularly banded.

268. Coal from Hsiwang-kan village, China.

Rather dull, thin banded.

269. Coal from Lao Tsa Gulley, China.

Dull, tender, obscurely banded.

270. Two varieties of Pung Chung coal, China.

Both are rather dull and irregular.

AUSTRALASIAN COALS.

271. Small samples of Australian coal, originally sent over to Sir R. I. Murchison.

These are severally :—1. Lustrous, black cannel, from Stony Creek. 2. Dull, earthy cannel, from Hartley. 3. Brown, lustrous cannel, from Lower Hunton. 4. Bright cannel, from Colley Creek. 5. Dull, earthy, carbonaceous shale, from Illawarra. 6. Brownish lignite, from Barragomerg. Accompanying them are some fossils of Palæozoic type.

272. Coal from Rosewood, Kendal county, Queensland. Of Carboniferous age. Analysed by W. J. Ward.

Carbon	68·28
Hydrogen	6·34
Oxygen and Nitrogen	9·08
Sulphur	0·40
Ash (pale red)	13·98
Water	1·92
	100·00

See Percy's Metallurgy, Fuel, p. 343. A massive, lignite-like, dull coal, yielding 50·35 per cent. of firm lustrous coke.

273. Coal from Flagstone Creek, Queensland. Of Carboniferous age. Analysed by W. J. Ward.

Carbon - - - -	59·41
Hydrogen - - - -	4·70
Oxygen and Nitrogen - - -	9·38
Sulphur - - - -	0·50
Ash (white) - - - -	22·12
Water - - - - -	3·89
	100·00

See Percy's Metallurgy, Fuel, p. 343. A moderately tender, irregularly banded coal, yielding 66·36 per cent. of firm lustrous coke. Communicated by R. Daintree.

274. "Allora" coal, Queensland; of Carboniferous age. Analysed by W. J. Ward.

Carbon - - - -	69·31
Hydrogen - - - -	6·08
Oxygen and Nitrogen - - -	11·51
Sulphur - - - -	0·31
Ash (buff) - - - -	8·87
Water - - - -	3·92
	100·00

A compact, rather dull, feebly banded coal, yielding 70·16 per cent. of coke and 25·92 per cent. of volatile matter. Communicated by R. Daintree, 1873.

275. "Thomas" coal, Queensland; of Carboniferous age. Analysed by W. J. Ward.

Carbon - - - -	59·69
Hydrogen - - - -	4·29
Oxygen and Nitrogen - - -	9·64
Sulphur - - - -	0·22
Ash (white) - - - -	24·25
Water - - - - -	1·91
	100·00

A bright coal, with irregular fracture, yielding 72·50 per cent. of coke and 25·59 per cent. of volatile matter. Communicated by R. Daintree, 1873.

276. "Davies" coal, Queensland; of Carboniferous age.

Carbon - - - -	79·01
Hydrogen - - - -	5·19
Oxygen and Nitrogen - - -	6·56

Sulphur - - - -	0·37
Ash (pale red) - - -	7·73
Water - - - - -	1·14
	100·00

A not brilliant, compact, and rather thin-banded coal, yielding 68·84 per cent. of coke and 30·02 per cent. of volatile matter. Communicated by R. Daintree, 1873.

277. Coal from New South Wales, imported in 1872.

A tender coal, with variable bands. Of probably Carboniferous age.

278. Coal from New South Wales, imported in 1872.

A dull, thin-banded, compact coal.

Both these coals were imported in H.M.S. "Eclipse" and communicated by the Sheerness officers. Dr. Percy gives (Metallurgy, Fuel, p. 344) two analyses of coals from this locality, but it is not indicated which of these correspond to either. They are—

	I.	II.
Carbon - -	77·65	65·11
Hydrogen - -	4·94	4·61
Oxygen and Nitrogen -	10·63	11·93
Sulphur - -	0·58	0·68
Ash - - -	3·25	7·12
Water - - -	2·95	10.55
	100·00	100·00

279. "Bulli" coal, Cumberland county, New South Wales; of Carboniferous age. Analysed by W. J. Ward.

Carbon - - - -	75·57
Hydrogen - - - -	4·70
Oxygen and Nitrogen - - -	4·99
Sulphur - - - -	0·54
Ash - - - - -	13·17
Water - - - - -	1·03
	100·00

See Percy's Metallurgy, Fuel, p. 344. A dull, tender coal, with broad bands, yielding 74·78 per cent. of coke.

280. Coal from New South Wales. Of Carboniferous age.

See "See Mines and Mineral Statistics of New South Wales," 1875. Bituminous coal from a ten foot seam. Australian Agricultural Company's Colliery, Newcastle. An excellent house, steam, gas, smelting, and caking coal. Brilliant, compact, scarcely banded. Communicated by J. Mackenzie, 1873.

281. Coal from New South Wales. Of Carboniferous age.

Bituminous coal from a ten feet seam. Lambton Colliery, near Newcastle. An excellent house, steam, gas, smelting, and caking coal. Bright, compact, and banded. Communicated by J. Mackenzie, 1873.

282. Coal from New South Wales. Of Carboniferous age.

Bituminous coal from a ten feet seam. Waratah Colliery, near Newcastle. An excellent house, steam, gas, smelting, and caking coal. Moderately bright, compact, and banded. Communicated by J. Mackenzie, 1873.

283. Coal from New South Wales. Of Carboniferous age.

Bituminous coal from the Dukinfield Colliery, near Newcastle. An excellent house, gas, steam, smelting, and caking coal. Compact, fairly bright, broad banded. Communicated by J. Mackenzie, 1873.

284. Coal from New South Wales. Of Carboniferous age.

Semi-bituminous coal from a ten feet seam. From the Bulli Colliery, near Wollongong. An excellent steam, smelting, and house coal. Dull, feebly banded, small splintering. Communicated by J. Mackenzie, 1873.

285. Coal from New South Wales. Of Carboniferous age.

Splint coal from a 26 foot seam. Greta Colliery, 35 miles from Newcastle. This seam of coal has 1 ft. of Boghead cannel in it. An excellent gas, steam, smelting, house, and coking coal. Bright, very compact, fine banded. Communicated by J. Mackenzie, 1873.

286. Coal from New South Wales. Of Carboniferous age.

Splint coal from a 10 ft. 6 in. seam. In the Upper Coal Measures, Lithgow Valley, County Cork. This seam is worked by the Bowenfels, Lithgow, Esk Bank, and Vale of Clwydd Colliery Companies. Very dull, compact, feebly banded. Communicated by J. Mackenzie, 1873.

287. Coal from Cape Paterson, near Victoria, New South Wales. Sent by A. Burrell.

Analyses are given by Dr. Percy, Metallurgy, Fuel, p. 344, of two samples of coal from this locality; but there is no indication as to which of these two specimens corresponds to the two analyses made by C. Tookey. They are—

	I.	II.
Carbon - -	77·65	65·11
Hydrogen - -	4·94	4·61
Oxygen and Nitrogen -	10·63	11·93
Sulphur - -	0·58	0·68
Ash - - -	3·25	7·12
Water - - -	2·95	10·55
	100·00	100·00

Of these two samples, one is more compact, regularly banded, and dull the other, more irregular, thinner banded, and brighter.

288. New Zealand coal. Bituminous non-caking coal from Brunner Mine, Nelson. From the exhibits of the Colonial Museum in the Vienna Exhibition, 1873.

Much jointed, homogeneous, tender and friable; lustre pitch-like, glistening; often iridescent; colour black, with a purple hue; powder, brownish; cakes strongly; the best varieties forming a vitreous coke with brilliant metallic lustre; average evaporative power 7½ lbs. of water per lb. of coal. Occurs with grits and conglomerates of Upper Neocomian age in seams 2 to 20 ft. in thickness.

289. New Zealand coal. Semi-bituminous coal from Preservation Inlet, Otago. From the exhibits of the Colonial Museum in the Vienna Exhibition, 1873.

Compact with laminæ of bright and dull coal alternately; fracture irregular; lustre moderate; cakes moderately, or is non-caking; rarely cakes strongly; evaporative power 6½ lbs. Occurs in thin irregular seams in sandstone of Upper Neocomian age.

290. New Zealand coal. Glance coal from Hills Drive, Malvern Hills, Selwyn, Canterbury. From the exhibits of the Colonial Museum in the Vienna Exhibition, 1873.

Non-caking, massive, compact, or friable; fracture cuboidal, splintery; lustre glistening to metallic; structure obviously laminated; colour black; does not form a compact coke, but slightly adheres. A variety of brown coal altered by faults or igneous rocks, and presenting every intermediate stage from brown coal to an anthracite.

291. New Zealand coal. Pitch coal from Shag Point, Otago. From the exhibits of the Colonial Museum in the Vienna Exhibition, 1873.

Of compact structure; fracture, smooth, conchoidal; jointed in large angular pieces; colour brown or black; lustre waxy; does not desiccate much on exposure, nor is it absorbent of water; burns freely, and contains resin distributed throughout its mass. Evaporative power 4·2 lbs. Derived from beds of Upper Neocomian age.

292. New Zealand coal. Brown coal from Saddle Hill Otago. From the exhibits of the Colonial Museum in the Vienna Exhibition, 1873.

Rarely shows vegetable structure; fracture irregular, conchoidal, with incipient laminations; colour dark brown; lustre feeble; cracks readily on exposure to atmosphere, losing 5 to 10 per cent. of water, which is not reabsorbed; burns slowly; contains resin in large masses. Evaporative power 5 lbs. From the lower part of beds of Upper Neocomian age.

293. Coal from the West Coast of the Middle Island, New Zealand. Analysed by C. Tookey. Of supposed Miocene age.

Carbon	79·00
Hydrogen	5·35
Oxygen	7·71
Nitrogen	0·89
Sulphur	2·50
Ash	3·50
Water	1·05
	100·00

See Percy's Metallurgy, Fuel, p. 344. Irregular, dull, small splintering coal, yielding 64·32 per cent. of coke. Communicated by C. L. Carter.

294. Coal from Kawa-Kawa, Auckland, New Zealand. Bituminous coal; of Tertiary age.

Contains	
Combustible matter	88·48
Sulphur	5·42
Ash	1·70
Water	4·40
	100·00

A dull, resinous looking coal, yielding 57 per cent. of coke. One ton occupies one cubic yard. Communicated by the Colonial Museum, New Zealand, 1868.

295. Coal from Grey River, Westland, New Zealand. Bituminous coal; of Tertiary age.

Contains	
Combustible matter	91·81
Ash	6·20
Water	1·99
	100·00

A bright, broad-banded, compact coal, yielding 68·7 per cent. of coke. One ton occupies ·999 cubic yards. Communicated by the Colonial Museum, New Zealand, 1868.

296. Coal from Buller River, Coalbrookdale, Nelson, New Zealand. "Nine-foot seam" of bituminous coal; of Tertiary age.

Contains	
Combustible matter	95·80
Sulphur	1·20
Ash	·40
Water	2·60
	100·00

A rather bright, very compact coal, yielding 65·8 per cent. of coke. One ton occupies 1·066 cubic yards. Communicated by the Colonial Museum, New Zealand, 1868.

297. Coal from Pakawan, Nelson, New Zealand. "Seven-foot" seam of bituminous coal; of Tertiary age.

Contains	
Combustible matter	87·14
Sulphur	1·04
Ash	8·26
Water	3.56
	100·00

A rather dull, very compact coal, with bright bands, yielding 58·8 per cent. of coke. One ton occupies ·909 cubic yards. Communicated by the Colonial Museum, New Zealand, 1868.

298. Coal from Acvere River, Nelson, New Zealand. A "one-foot" seam of bituminous coal; of Tertiary age.

Contains Combustible matter	94·00
Ash	3·80
Water	2·20
	100·00

A moderately dull, very compact, banded coal, yielding 58·5 per cent. of coke. Communicated by the Colonial Museum, New Zealand, 1868.

AFRICAN COALS.

299. Coal from Stormberg, Cape of Good Hope. Of Carboniferous age. Analysed by W. J. Ward.

Carbon	75·15
Hydrogen	4·55
Oxygen and Nitrogen	9·56
Sulphur	0·96
Ash	5·83
Water	3·95
	100·00

See Percy's Metallurgy, Fuel, p. 340. A bright, compact coal, with almost a conchoidal fracture, and yielding 67·88 per cent. of coke. *See* Dunn, Quart. Journ. Geol. Soc., vol. 27. Also Report on Stormberg Coalfield. Communicated by the Crown Agents, 1871.

300. Coal from Transvaal. Probably of Carboniferous age. Heavy, dull, and compact, very feebly banded.

301. Coal from Zambesi river, discovered by Dr. Livingstone. *See* "Expedition to the Zambesi and its Tributaries," 1865. Analysed by W. J. Ward.

Carbon	51·44
Hydrogen	3·16
Oxygen and Nitrogen	7·01
Sulphur	0·33
Ash	33·70
Water	3·86
	100·00

A compact, dull, irregularly banded coal, partly in loose particles. Communicated by the Admiralty.

302. Mineral found in the hills distant not more than 30 miles inland from Machinga Bay on the Zanzibar coast, a little to the south of Keleva. Found in 1878. Analysed by W. J. Ward.

Carbon	58·67
Hydrogen	4·57
Oxygen and Nitrogen	12·73
Sulphur	1·58
Ash	1·45
Water	21·00
	100·00

A compact cannel coal, resembling Wigan cannel, with a bright conchoidal fracture. Communicated by Dr. Kirk.

303. Coal from the Camdeboo Mountains, South Africa. Of Carboniferous age.

(*See* E. J. Dunn's "Report on the Camdeboo and Nieuwveldt Coal," Cape of Good Hope, 1879.) The coal called "Vices," middle portion, yields 19 per cent. of ash; 2·40 per cent. of water; 1·25 per cent. of sulphur; and 64 per cent. of fair coke. It is compact, dull, and narrow banded. Collected by E. J. Dunn.

304. Coal from Camdeboo Mountains, South Africa. Of Carboniferous age. (*See* **303.**)

"Vices" coal, bottom portion. Yields 17·80 per cent. of ash; 2 per cent. of water; 1 per cent. of sulphur; and 64 per cent. of fair coke. It is dull, compact, with narrow, bright bands. Collected by E. J. Dunn.

305. Coal from Camdeboo Mountains, South Africa. Of Carboniferous age. "Haltings" coal, middle portion.

Yields 29 per cent. of ash; 0·90 per cent. of water; 0·84 per cent. of sulphur. It is compact, tender, and banded alternately bright and dull, and an imperfectly caking coal. Collected by E. J. Dunn.

306. Coal from Camdeboo Mountains, South Africa. Of Carboniferous age. "Haltings" coal, bottom portion.

Yields 24 per cent. of ash; 1·30 per cent. of water; 1·05 per cent. of sulphur. It is a rather tender and thin banded non-caking coal. Collected by E. J. Dunn.

307. Coal from "November Kraal, Cape Colony."

Yields 23·60 per cent. of ash; 1·30 per cent. of water; 1·05 per cent. of sulphur. It is a tender, bright banded, non-caking coal. Collected by E. J. Dunn.

308. "Dundee" coal, from Natal.

A banded bituminous coal. Communicated by Ar. Browning.

Cokes.

309. Hair-like coke.

Produced by a bubble of hydrocarbon vapour being more highly heated, and decomposing, depositing its carbon on the surface; two such bubbles adjacent to each other build up thus a wall between them; and three produce a narrow thread standing out from the surface of the coke. *See* Percy's Metallurgy, Fuel, p. 421.

310. No. 1 Glamorgan coke.

311. No. 2 Glamorgan coke.

312. No. 3 Glamorgan coke.

313. Foundry coke. Newton, Chambers, and Co.

314. Coke used at the Tonddu Iron Works. Made from No. 3 coal. Mailts Moel Colliery, Ogmore Valley, near Bridgend, Glamorganshire.

315. Rhondda coke, in small fragments.

316. Anthracite coke. Made in an ordinary beehive oven by the Bouvilles Court Coal and Iron Company, Saundersfoot, S. Wales.

The ingredients used were anthracite slack, 70; bituminous slack, 25; and pitch, 5 per cent. A very brilliant but irregular coke.

317. Anthracite coke, made in an ordinary beehive oven, at the Kilgetty works of the Borwelle's Court Coal and Iron Company, 1873.

The ingredients used were, anthracite slack, 25; and bituminous or caking slack, 75 per cent. Less brilliant and irregular.

318. "Lowry" or "Parkend" coal, in the Forest of Dean and the coke that is made from it.

This is the only kind in use at the Cinderford furnaces (1875). *See* No. **170.** The coal is bright and slightly banded, the coke is pretty compact.

319. Coke used at the Parkend furnaces, Forest of Dean, made from the "Lowry" or "Parkend" High Delf coal.

320. Light coke, from the South Staffordshire thick coal.

Used in the blast furnaces, Russell's Hall, Dudley.

321. Medium coke from the South Staffordshire thick coal.

Used in the furnaces at Russell's Hall, Dudley.

322. Heavy coke from the South Staffordshire thick coal, Russell's Hall, Dudley.

A very dense and lustrous coke, capable of bearing a heavy burden.

323. Slack coke made from the South Staffordshire ten yard or thick coal, Dudley.

In small pieces. Communicated by S. Blackwell.

324. Coke produced by a mixture of equal weights of pitch and the slack of South Staffordshire thick coal. (1859.)

Coked in Jones' coke oven, at the Russell's Hall Furnaces, Dudley, of which a full description is given in Percy's Metallurgy, Fuel, p. 438. The resulting coke is used in the blast furnaces. It is dull and very regularly scoriaceous. Communicated by S. Blackwell.

325. Light coke from the Heathen coal. South Staffordshire, Russell's Hall, Dudley.

326. Coke from Peareth gas coal.

Made by exposing the pulverised coal to a dull red heat in a Stourbridge clay crucible, until the evolution of gas ceased.

327. Two samples of coke from Peareth gas coal.

Prepared at a low temperature, by exposing the finely pulverised coal to a full red heat for about three-quarters of an hour, and increasing the heat for a few minutes. The crucible was embedded in a second pot filled with anthracite, to exclude air. Experiment by R. Smith. (1856.)

In one of these samples the pulverised coal was inserted dry; in the other it was previously wetted and rammed in.

328. Coke from Peareth gas coal.

Prepared at a high temperature by exposing the finely pulverised coal to a bright red heat for about an hour, the crucible being embedded in anthracite. In one of the two samples the powder was dry; in the other it was wetted with water and well rammed down in the crucible. Experiment by R. Smith. (1856.)

329. Coke from an old gas retort at Leith, near Edinburgh. (1840.)

Showing a laminated structure, and of a highly specific gravity.

330. Coke from steam coal obtained at Seaton Burn Colliery, near Newcastle-on Tyne. (1856.)

Produced by exposing the pulverised coal to a dull red heat in a covered Stourbridge clay pot until evolution of gas ceased; time about 1 hour.

331. Coke from the Abercarn Black Vein steam coal, Newport, Monmouthshire. Analysed by E. Jackson.

Carbon - - - -	89·38
Hydrogen - - - -	1·27
Oxygen and Nitrogen - - -	0·57
Ash - - - - -	8·78
	100·00

Contains 0·45 per cent. of moisture and 0·75 per cent. of sulphur.

332. Coke produced from the Tertiary lignite of Bovey Tracey, Devonshire, without pulverisation.

Very light and charcoal-like.

333. Coke prepared at a high temperature from the "White" coal, Whyley Pit, South Staffordshire.

The very finely powdered coal was placed in a covered Cornish crucible, enclosed in a Stourbridge clay pot, filled up with anthracite powder to exclude the air. It was then heated as rapidly as possible at a strong red heat for rather more than half an hour. This coke shows well the arborescent and mammilated form produced on the surface by the rapid and irregular evolution of gas. A little further subdivision would produce the hair-like coke, No. **309.**

334. Coke prepared as **324**, part, in fact, of the same preparation.

And showing a quantity of hair-like coke in the crevices where the main mass has separated, the crevices being closed at the surface and wider below. One of these is filled, not with round hairs, but with thin plates. A finely laminated coke.

335. Result of heating pulverised "Thick coal" in a furnace for half an hour, the temperature being raised as rapidly as possible.

Forms a pulverulent and scarcely coherent coke. Experiment by R. Smith. (1855.)

336. Patent coke. From the Glamorgan Coal Company, South Wales, No. 1. Analysed by W. J. Ward. (1878.)

Carbon	85·73
Hydrogen	0·73
Oxygen and Nitrogen	0·88
Sulphur	0·74
Ash	8·08
Water	3·84
	100·00

A very porous coke. Communicated by W. Perch and Co.

337. Patent coke from the Glamorgan Coal Co., South Wales, No. 2. Analysed by W. J. Ward.

Carbon	92·73
Hydrogen	0·64
Oxygen and Nitrogen	0·60
Sulphur	0·79
Ash	4·87
Water	0·37
	100·00

338. Coke used for iron smelting at the Dunbar Ironworks, Pennsylvania. A strong lustrous coke. Analysed by Mr. Habrishaw. It contains—

Carbon	89·047
Volatile matter	1·296
Sulphur	0·184
Water at 125° C.	0·032
Ash	9·523
	100·032

The ash is composed of silica 5·413, alumina 3·272, ferric oxide 0·479, lime 0·243, and phosphoric acid 0·012.

339. Coke produced from the slack of the Main Seam Albion Mines, Pictou County, Nova Scotia.

Communicated by G. M. Dawson.

PATENT FUELS.

340. Dawson's Patent Fuel.

Produced by the subjection of coal slack to heat and pressure. (1851.)

341. Portion of the fuel which oozes out from the iron box during the process of compressing the slack in Dawson's patent process.

342. The coal powder which is moistened with water and afterwards subjected to heat and compression in the manufacture of patent fuel by Dawson's process. (1856.)

343. Venallt Patent Fuel, South Wales.

Made by compressing slack combined with a bituminous substance. Communicated by Wm. Gregory.

344. Patent fuel in cylinders made by the compression of slack.

Four samples. 1. Suitable for locomotives and steamships. 2. From steam coal. 3. From anthracite. 4. From bituminous coal.

345. Mineral charcoal. Two samples from different coals.

It is light and porous and easily broken. Used as a substitute for wood-charcoal in the manufacture of tin-plate iron. The coal is powdered and washed and spread in its wet state over the floor of a reverberatory furnace previously heated to redness. Much ebullition and evolution of gas occurs and the residue in about an hour is the mineral charcoal.

346. Samples of Barker's Patent Fuel.

Produced by mixing fragments of coke or coal with farinaceous matter, and subjecting them to compression. No. 1 is made from coke.

No. 2 is the same material which has been re-coked in an oven. No. 3 is made from "Nixon's Navigation" coal. No. 4 from Powell's Duffryn coal; and No. 5 from Lambton's Wallsend.

REFRACTORY MATERIALS FOR FURNACES, &c.

Clays, Bricks, and Sandstones.

347. Stannington fire-clay. From carboniferous beds in the Sheffield District.

It is used for cast-steel pots. After desiccation its analysis gives:—

Silica	48·04
Alumina	34·47
Earths and Alkalies	3·05
Iron Oxide	3·05
Water in combination	11·15
	99·76

See Percy's Metallurgy, Fuel, &c., p. 98.

348. Edgemount pot-clay. From carboniferous beds near Sheffield.

Used in making crucibles for melting cast-steel. Its analysis by W. J. Ward, after desiccation, gives:—

Silica	45·73
Alumina	34·14
Alkalies and Earths	1·98
Iron Oxide	1·76
Water combined	10·17
Water hygroscopic	4·45
Organic matter	0·70
	98·93

See Percy's Metallurgy, Fuel, &c., p. 98. Communicated by Mr. S. Morgan. It is accompanied by samples ground and burnt.

349. Fire-clay from Edensor. From carboniferous beds near Derby.

Used in making crucibles for cast-steel. After desiccation its analysis gives:—

Silica	48·08
Alumina	36·89
Alkalies and Earths	2·43
Iron Oxide	2·26
Water combined	10·87
	100·53

See Percy's Metallurgy, Fuel, &c., p. 98.

350. Carboniferous fire-clay from Buckley Mountain, Flintshire.

The lowest bed and best quality worked. Burns white, and is largely used for fire-bricks at the Holywell Lead Furnaces and at Swansea.

351. Teignmouth clay, Devonshire, known as the chocolate variety. It is used as an ingredient in Juleff's crucibles.

It really occurs at Bovey Tracey, but is called Teignmouth clay from its port of shipment. It is a white Tertiary clay, and its analysis by W. Weston gives:—

Silica	52·06
Alumina	29·38
Alkalies and Earths	2·74
Iron Oxide	2·37
Water combined	10·27
Organic matter	traces.
Water hygroscopic	2·56
	99·38

See Percy's Metallurgy, Fuel, &c., p. 99.

352. Clay from Poole, Dorsetshire.

A white Tertiary clay used as an ingredient in Juleff's crucibles. Its analysis gives:—

Silica	48·99
Alumina	32·11
Alkalies and Earths	3·96
Iron Oxide	2·34
Water combined	9·63
Water hygroscopic	2·33
	99·36

See Percy's Metallurgy, Fuel, &c., p. 99.

353. China clay from South Cornwall Mining Company's Works.

It is a white clay derived from the decay of the neighbouring granite. Analysed by W. J. Ward, after desiccation.

Silica	47·75
Alumina	38·11
Alkalies and Earths	0·91
Iron Oxide	0·69
Water combined	12·54
	100·00

See Percy's Metallurgy, Fuel, &c., p. 100.

354. Fire-clay from the Star Fire-brick Works, Glenborg, near Coat Bridge, N.B.

Used for fire-bricks, Bessemer tuyères, &c. A dark, carbonaceous, hard, sandy clay. Communicated by J. Dunnachie.

355. Black Stourbridge fire-clay, used for making "London pots" by the Patent Plumbago Crucible Company, Battersea.

A carboniferous under-clay.

356. French fire-clay, used in making French crucibles by the Patent Plumbago Crucible Company, Battersea.

See Percy's Metallurgy, Fuel, &c., p. 121. A sandy loose clay.

357. White Stourbridge fire-clay, used for making "Glass pots" by the Patent Plumbago Crucible Company, Battersea.

A strong brown sandstone. Communicated by Mr. Gadby.

358. Red clay, Devonshire. Analysed by W. J. Ward.

Silica	57·83
Alumina	20·55
Ferric Oxide	7·75
Manganous Oxide	trace.
Magnesia	0·97
Lime	1·68
Potash	3·87
Soda	0·56
Carbonic Acid	0·90
Phosphoric Acid	trace.
Water combined	4·39
Water hygroscopic	2·13
	100·63

In its moist state it contained 24·42 per cent. of water. A uniform red clay apparently derived by weathering from the Trias clays.

359. Belgian clay, imported into Swansea for zinc retorts.

See Percy's Metallurgy, Fuel, p. 122. A soft grey clay.

360. "China stone" from the Isle of Man.

A white siliceous material used for brick-making for furnaces, from the ancient schists of the island. A portion of it tested in a crucible by Mr. R. Smith accompanies the mass. Communicated by A. Klingenden.

361. Sand as occurring at S. Agnes Beacon, Cornwall. One of the ingredients of Juleff's Cornish crucibles.

Communicated by Mr. Gadby.

362. Prepared composition of Juleff's Cornish crucibles, Redruth.

It consists of one part of Teignmouth clay (No. **351**), one part of Poole clay (No. **352**), and two parts of sand from S. Agnes Beacon, Cornwall (**361**), all by measure, and is yellowish white and granular. *See* Percy's Metallurgy, Fuel, p. 118. Communicated by Mr. Gadby.

363. China stone from Cornwall.

A green siliceous stone, accompanied by specimens of the result of fusing it in a platinum crucible.

364. Result of trials with Glascote fire-clay, from near Tamworth.

See Percy's Metallurgy, Fuels, &c., p. 99. It is cut into trial pieces of the form described and figured, loc. cit., p. 113.

365. Tested clays from the Rockingham Clay Works, West Willow, Romsey, Hants.

White uniform clays. Communicated by Mr. Sturgeon.

366. Fire-clay from Way Wood, with the results of testing the same.

A hard, micaceous, gritty, banded rock. Communicated by Mr. Dougall Smith.

367. The original rock from whence is derived the material for the "Dinas fire-bricks."

A very hard, compact, siliceous rock, found at Dinas, in the Vale of Neath, Glamorganshire. Too hard to be worked by itself. Analysed by W. Weston. Communicated by E. Young.

Silica	96·73
Alumina	1·39
Iron Oxide	0·48
Lime	0·19
Alkalies	0·20
Water combined	0·50
	99·49

See Percy's Metallurgy, Fuels, &c., p. 147.

368. The weathered material actually used for the Dinas bricks.

It occurs in the soft, crumbly state, as well as in the condition of hard rock, but the latter is known to become softer by weathering.

369. The prepared material used for the manufacture of Dinas bricks, consisting of the rock ground with one per cent. of lime.

See Percy's Metallurgy, Fuel, &c., p. 147.

370. The varieties of material required for the manufacture of Devonshire fire-bricks.

They are all derived from the decomposition of granite, and for use the best composition is found to be one part of "coarse mica" and two parts of "fine sand." The several varieties are as follows:—1. "Coarse sand." This consists of the larger masses of quartz which are separated from the kaolin used for china clay. 2. "Fine sand." This consists of the finer particles of quartz, mixed with much of the mica, and a small proportion of some more basic ingredient of dark tint. 3. "Pipe clay." This is the separated kaolin. 4. "Coarse mica." This consists of the kaolin mixed with the larger fragments of partially decomposed mica. 5. "Fine mica." This consists of the kaolin mixed with the finer fragments of the mica.

371. Soft, white, friable, siliceous material between Great and Little Ormes Head, near Llandudno.

Suitable, when mixed with a little clay, for furnaces and the setting of fire-bricks, but used also for building and shipped as ballast.

372. Aluminous mineral from Ireland (? from Belfast).

With results of testing it (1) by heating alone, (2) by mixing it with 10 per cent. of French fire-clay, (3) by mixing it with 20 per cent. of French fire-clay.

373. Fragments of the Pennant grit rock, a coarse sandstone belonging to the Coal Measure series, which have been built into the Gwyther Old Furnace, South Wales, and have, therefore, long been subjected to heat, of which the effects may be seen in the specimens.

374. Sandstone used for hearth stone in the Glyndon Furnace on the river Lehigh, Easton, Carbon County, Pennsylvania, U.S.A.

A coarse siliceous grit.

375. Columnar structure produced at Glyndon Furnace, Lehigh River, Pennsylvania.

This is formed at the mouth of the furnace, of the sandy loam used in closing up the outlet after casting. It is black and hard, but comparatively light.

376. Samples of Dinas fire-bricks.

The fracture is very rough, owing to the irregular white particles of quartz which are set in a yellowish matrix.

377. Material of which the Dowlais fire-brick is made.

It is known as the "Little Vein West Clay." Analysed when burnt into brick by E. Riley, and yields :—

Silica - - - - -	63·09
Alumina - - - -	29·09
Earth and Alkalies - - -	2·65
Iron Oxide - - - -	2·88
Titanic Acid - - - -	2·21
	99·92

See Percy's Metallurgy, Fuel, &c., p. 150.

378. Sample of material and results of experiments on "Windsor bricks."

These bricks are red, and known as PP. fire-bricks, and are made at Chalfont St. Peters, Buckinghamshire. The material is a soft, red, argillaceous sandstone. *See* Percy's Metallurgy, Fuel, p. 150, where an analysis is given.

379. Buckley fire-brick, used for lead smelting furnaces.

From Buckley, in Flintshire; a specimen brought from the Dee Bank Lead Works. It is a very coarse yellowish red brick, with particles of unaltered white silica; also used for parts exposed to great heat in chimneys, flues, &c. *See* Percy's Metallurgy, Fuels, &c., p. 150, where an analysis is given.

380. Stormy fire-brick; formerly used as a substitute for Dinas bricks.

This is a siliceous brick made from boulders scattered over Lias Limestone, near Bridge End, Pyle, Glamorganshire. These were collected and ground, but the manufacture has been discontinued as too expensive, and the resulting brick too tender.

381. A portion of brick made by the Chinese on the Bendigo Gold Fields.

They take the clay and knead it with "sludge," mould it into bricks and burn them in a kiln, somewhat resembling a conical coke oven, but very large. About half-way up the interior of the kiln are four openings for piping, one and a half inch diameter, through which they force water by means of a pump. The bricks are carefully packed so as to let as much surface as possible come in contact with the hot air and steam.

382. Fragment of reddish white fire-brick from India; together with the results obtained by R. Smith in testing its power of resisting fusion, showing it to fuse slightly.

Communicated by H. Bauerman.

383. Sand as used for beds of copper furnaces.

384. Tanners spent bark, burnt into ashes, and sieved ready for mixing in water with which to wash the inside of copper cake moulds.

385. Ganister used for furnace bottoms.

From the quarry at Hazlehead, near Penistone. Communicated by Sir J. Brown and Company.

386. Gornal sandstone altered by heat. From the hearth of the blast furnace, Woodside.

It has become roughly columnar in structure with slickensides. Communicated by A. B. Boden.

387. Specimen showing the action of silicate of iron upon a Cornish crucible.

It has invaded the substance of the crucible and divided it into numerous irregular lamellæ, which are filled with the melted substance in a glassy form.

388. Specimen showing the action of oxide of iron on a fire-brick of inferior quality from Sielce.

It has entered into combination, and is commencing to perforate the brick.

GRAPHITE.

389. Natural graphite from Ceylon.

As used by the Patent Plumbago Crucible Company in making "black-lead" crucibles. It is very massive, with a fibrous striation.

390. Native graphite from the Horicon Mines, Triconderoga, on Lake Champlain, U.S.A.

The mass is divided into bands from $\frac{3}{8}$ to $\frac{3}{4}$ inch in thickness, and the finer foliæ of graphite cross these bands obliquely, and at different angles in different bands.

391. Native graphite from the Horicon Mines, Triconderoga.

Showing a crystalline or platy form. It is very irregular, and apparently from a disturbed mass.

392. Native graphite from the Horicon Mines, Triconderoga.

Showing a massive form, with an indefinite number of fine bands of irregular form, each of which is produced by very fine transverse, crystalline plates set side by side.

These three samples are all from the "Laurentian" rocks of the State of New York, where they occur in bands.

393. Sample of purified graphite from Horicon Mines, Triconderoga.

This is called "Photographers' graphite," and is purified first mechanically, and then chemically, so that the remaining impurity does not exceed 0·5 per cent. From the American Graphite Company, New York.

394. Sample of purified graphite from Horicon Mines, Triconderoga.

This is called "Electrotypers' graphite," and is purified by mechanical means only. From the American Graphite Company, New York.

395. Specimen of the material used in making the Morgan crucibles.

This has been tested in the Metallurgical Laboratory of the Royal School of Mines by incineration in a muffle heated to whiteness, and it has yielded 51·66 per cent. of a yellowish-white residue, giving 48·34 per cent. of graphite. *See* Percy's Metallurgy, Fuel, &c., p. 126.

396. Plumbaginous or graphitic anthracite from the mica schists of Worcester, 45 miles west of Boston, U.S.A. Brought by Sir Chas. Lyell. Analysed by Dr. Percy.

Carbon - - - -	28·350
Hydrogen - - - -	0·926
Oxygen and Nitrogen - - -	2·155
Ash - - - - -	68·569
	100·000

A well-banded mass very graphitic in appearance. *See* Quart. Journ. Geol. Soc., vol. I., p. 205.

Casting Materials, &c.

397. Casting sand from Birmingham.

A fine red sand from below the Bunter series. It takes a sharp mould. Communicated by J. P. Marrian.

398. Casting sand from Japan.

From a core in which it had been used. Analysed by W. J. Ward, including the fragments of charcoal with which it is mixed.

Silica - - - - -	67·60
Alumina - - - -	17·64
Iron Oxides - - - -	3·90
Oxides of Copper, Zinc, and Manganese	0·91
Earths and Alkalies - - -	6·10
Sulphuric Acid - - -	0·09
Carbon - - - -	1·76
Water - - - - -	1·78
	99·78

See Percy's Metallurgy, Fuel, &c., p. 153. Communicated by J. Fisher.

399. Substance of the mould used for large steel castings at Messrs. Spear and Jackson's Atlas Works, Sheffield, 1885.

It is very hard and dark grey, and seems to contain much graphite, but its actual composition is not stated.

400. Loam used for casting moulds and cores at the Woolwich Arsenal.

COPPER.

Experiments showing the Properties of Copper.

401. Copper scale.

Consists almost wholly of copper dioxide. It is largely produced in the process of annealing sheet copper in rolling mills, with access of air. *See* Percy's Metallurgy, 1861, p. 242.

402. Pulverized copper scale

403. Copper scale heated to redness with access of air, and thereby converted into cupric oxide.

404. Cuprous oxide, produced by heating cupric oxide with copper.

A hard red mass of artificial cuprite, an important ore of copper.

405. Cuprous oxide, produced by heating one equivalent of copper sulphide with two equivalents of copper sulphate at a low heat in a covered pot.

200 grains of copper sulphide and 400 grains of copper sulphate were taken. Experiment by W. Baker, 1854.

406. Cuprous oxide, produced by heating one equivalent of cuprous sulphide with four of cupric sulphate.

300 grains of copper sulphide with 1,200 grains of cupric sulphate were heated together in a covered pot to a low red heat. Experiment by W. Baker.

407. Cuprous oxide, produced by heating five equivalents of cuprous chloride and three of sodium carbonate, and digesting the product in water.

408. Cupric oxide exposed to a high temperature.

It has melted to a purple slag-like mass.

409. Result of heating silica with cuprous oxide in the proportion of 30 to 70, or 3 Cu_2O, 2 SiO_2. Conducted by R. Smith.

The mixture was heated strongly in a plumbago crucible. The product was fritted, but not melted, and forms a hard earthy red mass. *See* Percy's Metallurgy, 1861, p. 243.

410. Result of heating silica with cupric oxide in the proportion of 84 : 116, or CuO, SiO_2. Conducted by R. Smith.

This was exposed to an intense heat in a French pot for about two hours. This only partially softened, but did not entirely fuse the mixture, producing an earthy, irregular, black and red banded mass. *See* Percy's Metallurgy, 1861, p. 244.

411. Result of heating silica with cupric oxide in the proportion of 44 : 58, or 3 CuO, 2 SiO_2. Conducted by R. Smith.

The materials were intimately mixed, and the mixture exposed in an uncovered platinum dish to a strong red heat in a muffle during 3½ hours, about half the product was again exposed during 5½ hours to a heat approaching whiteness. No perceptible change occurred. The results of both are here. They are dark earthy masses with a red fracture. *See* Percy's Metallurgy, vol. I., p. 244.

412. Bisulphide of copper.

Produced by the direct combination of flowers of sulphur with copper scale. It is black, with fine radiating crystals from the sides of the crucible.

413. Result of the experiment of heating cuprous oxide with iron bisulphide and silica.

1,296 grains of cuprous oxide were mixed with 786 grains of bisulphide of iron and 276 grains of silica, and heated in a plumbago crucible with charcoal. The result is threefold: at the top is a smooth compact slag, in the middle is a regulus-like bisulphide of copper showing a little moss-copper here and there, and a button of copper through which bisulphide of copper is diffused. Experiment by R. Smith, 1856. *See* Percy's Metallurgy, 1861, p. 255.

414. Bisulphide of copper.

Produced by fusing six equivalents of cupric oxide, six of pyrites, and two of silica. Yielding two of silicate of iron and six of bisulphide of copper. A steel-grey mass of metallic lustre.

415. Copper bisulphide coating the surface of copper foil.

Produced by leaving the foil in a flask with flowers of sulphur at the ordinary temperature of the air for some days, whereby it has become quite black by being covered by a loose layer of sulphide.

416. Copper bisulphide.

Produced by heating together copper wire and sulphur in a flask. The form of the fragments of copper wire is not lost, but they are converted nearly or quite to the centre into the above-named black compound.

417. Artificial copper pyrites.

Produced by fusing copper bisulphide with two equivalents of iron bisulphide or native iron pyrites. Two atoms of sulphur are expelled, leaving a double sulphide of the formula $Cu^2S + 2\,FeS$ containing by analysis 30·39 per cent. of sulphur. 1,000 grains of Cu^2S and 1,513 of FeS^2 were taken. It is of a dull brass yellow colour. Experiment by W. Baker, 1854. *See* Percy's Metallurgy, 1861, p. 247.

418. Artificial copper pyrites.

Produced by fusing together copper bisulphide with two equivalents of iron sulphide, adding sulphur in pieces and stirring with a wooden rod. 1,000 grains of Cu^2S and 1,109 grains of FeS were taken, and the analysis of the product gave sulphur 29·6 per cent. The formula $Cu^2S + 2\,FeS$ corresponds to 28·69 per cent. of sulphur, showing that no more was taken into composition. Experiment by W. Baker. *See* Percy's Metallurgy, 1861, p. 247.

419. Massive bisulphide of copper.

Artificial copper-glance, consisting of dull black square prisms one inch in the side.

420. Artificial copper pyrites.

Produced by fusing together one equivalent of copper bisulphide and one of iron sulphide. 320 grains of the former and 176 grains of the latter were taken and fused in a covered crucible, producing 450 grains of pyrites, much resembling the "blue-metal" of copper smelters. *See* Percy's Metallurgy, 1861, p. 247.

421. Artificial bisulphide of copper.

Produced by fusing copper scrap and sulphur on a large scale (30 lbs.). It shows crystals arranged in an arborescent form, and having a brassy lustre. Experiment by W. Ratcliffe, Wolverhampton, 1876.

422. Copper produced by mixing copper bisulphide with two equivalents of cuprous oxide.

There were heated together in a luted pot for 25 minutes at a strong red heat 1,000 grains of Cu^2S and 1,796 grains of Cu^2O. The copper obtained weighs 2,301 grains. Experiment conducted by W. Baker, 1854. *See* Percy's Metallurgy, 1861, p. 250.

423. Copper produced by mixing copper bisulphide with two equivalents of cupric oxide.

1,000 grains of each ingredient were taken and heated together in a luted pot at a strong red heat. The button of copper weighed 1,295 grains. Experiment conducted by W. Baker, 1854. *See* Percy's Metallurgy, 1861, p. 250.

424. Copper produced by mixing one equivalent of copper bisulphide with one of copper sulphate.

500 grains of each were taken and heated in a luted crucible for 25 minutes at a strong red heat. The button of copper weighed 516 grains. Experiment conducted by W. Baker, 1854. *See* Percy's Metallurgy, 1861, p. 250.

425. Result of experiment to show the action of silica in melting copper bisulphides in an earthen crucible.

One equivalent of copper bisulphide and four of copper sulphate were mixed and heated at a regulated temperature until converted entirely into cupric oxide. The heat was then increased, and the oxide of copper combined with the silica contained in the pot, forming a very fusible silicate. This was poured out into a mould, forming a dark brown massive substance (here broken in two), and a portion of the corroded pot preserved, showing an irregular black surface and discoloured section. Experiment conducted by W. Baker, 1854. *See* Percy's Metallurgy, 1861, p. 250.

426. Result of heating four equivalents of copper with one of protoxide of lead.

320 grains of granulated copper were fused with 280 grains of litharge, the resulting metallic button weighed 340 grains, and was accompanied by a red-brown slag. It contained 308·4 grains, or 90·7 per cent. of copper. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 250.

427. Result of heating two equivalents of copper with one of protoxide of lead.

320 grains of copper and 560 grains of protoxide of lead were fused together, and the product consisted of 340 grains of red metal accompanied by a red brown glassy slag.

428. Result of heating one equivalent of copper with one of protoxide of lead.

320 grains of copper and 1,120 grains of litharge were fused together, and the product consisted of 321 grains of metal and of red-brown slag. The button contained 233·7 grains, or 72·8 per cent. of copper. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 251.

429. Result of heating one equivalent of copper with two of protoxide of lead.

320 grains of copper and 2,240 grains of litharge were fused together and a button of metal weighing 392 grains was obtained, and in a second experiment when the copper was granulated, 373 grains, accompanied by a mottled slag. The button, in the last case, contained 203·9 grains, or 54·66 per cent. of copper. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 251.

430. Result of heating one equivalent of copper with three of protoxide of lead.

160 grains of copper and 1,680 grains of litharge were fused together, and a button of metal weighing 195 grains was obtained. The slag shows two layers, the upper one rich in copper, the lower one rich in lead. The button contained 56·9 grains, or 29·2 per cent. of copper. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 251.

431. Result of heating one equivalent of copper with six of protoxide of lead.

64 grains of copper and 1,344 grains of litharge were fused together, and a button of metal weighing 86 grains was obtained. The slag is dark brown and vitreous. The button resembled lead, and contained 10·6 grains, or 12·3 per cent. of copper. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 251.

432. Result of heating two equivalents of copper and one of sulphate of lead.

320 grains of copper and 760 grains of lead sulphate were heated together. The reaction only takes place at a strong red heat. The slag produced is dark and scoriaceous on the surface, and brick red below. Two globules of copper weighing 11·1 grains were left. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 252.

433. Result of heating one equivalent of copper with one of sulphate of lead.

160 grains of copper and 760 grains of lead sulphate were heated together. There were no globules of copper, and the slag weighed 640 grains. It is brownish red, with a darker and sub-metallic surface. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 252.

434. Result of heating two equivalents of cupric oxide with one of metallic lead.

800 grains of the cupric oxide and 1,040 grains of granulated lead were fused together, yielding a crystalline black slag with semi-metallic lustre. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 253.

435. Result of heating three equivalents of cupric oxide and two of metallic lead.

480 grains of cupric oxide and 832 grains of lead were fused together. The resulting metallic button weighed 460 grains, and contained 330·7 grains, or 71·9 per cent. of copper. The slag is reddish brown, and semi-vitreous. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 253.

436. Result of heating one equivalent of cupric oxide with one of metallic lead.

400 grains of cupric oxide and 1,040 grains of lead were fused together. The resulting metallic button weighed 343 grains. The experiment was repeated on half the above quantities, and the metallic button weighing 180 grains contained 119·7 grains, or 66·5 per cent. of copper. The slag is reddish brown. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 253.

437. Result of heating one equivalent of cupric oxide with two of metallic lead.

200 grains of cupric oxide were fused with 1,040 grains of lead. The resulting button weighed 574 grains, consisting of lead mixed with copper. It is accompanied by a black, highly vitreous slag, which is reddish brown in thin flakes. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 253.

438. Result of heating one equivalent of cuprous oxide with one equivalent of oxide of lead.

720 grains of copper scale and 1,120 grains of litharge were fused together at a low red heat, producing this dark crystalline mass. It shows signs of contraction on cooling. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 253.

439. Result of heating one equivalent of cuprous oxide with two of oxide of lead.

720 grains of cuprous oxide were fused with 2,240 grains of litharge. Produces a similar dark crystalline mass, the upper coat of sub-metallic lustre, but no lead is formed. The mass has a contraction cavity in the centre. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 253.

440. Result of heating one equivalent of cupric oxide with one of oxide of lead.

400 grains of cupric oxide were heated with 1,120 of litharge. The result is a hard dark crystalline slag. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 253.

441. Result of heating one equivalent of cupric oxide with two of oxide of lead.

200 grains of cupric oxide were fused with 1,120 grains of litharge. The result is a dark greenish slag, with radiating crystallisation and hollow centre. Experiment by R. Smith. *See* Percy's Metallurgy 1861, p. 253.

442. Result of heating one equivalent of cupric oxide with one of lead sulphide.

400 grains of cupric oxide were fused with 1,200 grains of pure galena, and produced a button of regulus weighing 705 grains, together with a black vitreous slag. The experiment was repeated with half quantities, and the button weighing 302 grains, yielded 142·3 grains, or 47·15 per cent. of copper. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 254.

443. Result of heating three equivalents of cupric oxide with two of lead sulphide.

600 grains of cupric oxide were fused with 1,200 grains of galena, and produced a regulus weighing 710 grains, with a button of metal below. It contained 504 grains, or 71·04 per cent. of copper. There is also a vitreous brown-red slag. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 254.

444. Result of heating two equivalents of cupric oxide with one of lead sulphide.

800 grains of cupric oxide were fused with 1,200 grains of galena, and produced a regulus with a copper-coloured button at the bottom. The whole weighed 565 grains, of which the button was 307 grains, containing 299 grains, or 97·4 per cent. of copper. The slag is a hard sealing-wax-red opaque glass. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 254.

445. Result of heating three equivalents of cupric oxide with one of lead sulphide.

1,000 grains each of cupric oxide and galena were fused together, and produced a brownish-red slag, with a button of metal weighing 140 grains, of which 138·6 grains, or 99 per cent., is copper; the slag only is here. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 254.

446. Result of heating four equivalents of cupric oxide with one of lead sulphide.

800 grains of cupric of oxide were fused with 600 grains of galena, and produced a red opaque slag and a copper-like button weighing 162 grains, and containing 156·7 grains, or 96·7 per cent. of copper; the slag only is here. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 254.

447. Result of heating sulphide of copper with carbon.

200 grains of copper sulphide were exposed to a high temperature in a brasqued crucible, and produced 8·5 grains of metallic copper, with 189·5 grains of unchanged sulphide. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 257.

448. Result of heating one equivalent of sulphide of copper with one of iron.

1,000 grains of copper sulphide were fused with 353 grains of iron filings in a crucible with a luted cover, for about 20 minutes at a strong red heat, and produced a regulus and a button of metal weighing 853 grains. This button, analysed by Mr. Tween, gave copper 62·45, iron 31·70, and sulphur 3·85 per cent. Experiment by W. Baker. *See* Percy's Metallurgy, 1861, p. 257.

449. Result of heating one equivalent of sulphide of copper with two of iron.

1,000 grains of copper sulphide and 700 grains of iron filings were fused together, and produced a brittle crystalline regulus of iron-grey colour. Experiment by W. Baker, 1854. *See* Percy's Metallurgy, 1861, p. 257.

450. Result of heating two equivalents of sulphide of copper with one of iron.

1,000 grains of copper sulphide were fused with 910 grains of iron in a luted crucible and anthracite fire for 45 minutes, and produced a purple-coloured regulus and no metal. Experiment by W. Baker, 1854. *See* Percy's Metallurgy, 1861, p. 257.

451. Yellow copper ore fused and stirred with metallic iron.

This illustrates the statement (Percy's Metallurgy, 1861, p. 258) that metallic iron exerts little reducing effect upon the double sulphide of copper and iron, the result being still the compound sulphide, rather browner and dark in the middle by the introduction of a larger proportion of iron.

452. Result of heating one equivalent of sulphide of copper with four of iron.

1,000 grains of copper sulphide were fused with 1,410 grains of iron filings in a luted pot with anthracite for 45 minutes, and produced a dark grey regulus, which is crystalline, except its upper layer, and transfused in it is a certain amount of moss-copper, and a few crystals like those of copper sulphide. Experiment by W. Baker, 1854. *See* Percy's Metallurgy, 1861, p. 258.

453. Result of heating one equivalent of copper sulphide with one of zinc.

320 grains of copper sulphide were fused with 128 grains of zinc in fine powder in a luted crucible at a bright red heat for 20 minutes, and the result weighed 246 grains. It consists of a thin layer of bluish-grey regulus and a metallic button-like brass; the regulus contains 58·4 per cent. and the button 81·8 per cent. of copper. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 258.

454. Result of heating one equivalent of copper sulphide with two of zinc.

160 grains of copper sulphide were fused with 128 grains of zinc at a bright red heat; the result weighed 182 grains, consisting of a layer of regulus weighing 119 grains, and a button of metal weighing 63 grains. The regulus has its upper surface partially covered with moss-copper, and contains 62·37 per cent. of copper. The button contains 80·9 per cent. of copper. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 258.

455. Result of heating one equivalent of copper sulphide with one of lead.

400 grains of copper sulphide were fused with 520 grains of finely granulated lead in an unluted crucible. The result is a dark grey regulus, and a button of malleable metal weighing 495 grains, of which 10·3 per cent. is copper. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 258.

456. Result of heating two equivalents of copper sulphide with three of lead.

400 grains of copper sulphide were fused with 780 grains of lead, and the result is a dark grey regulus, and a button of malleable metal weighing 753 grains and containing 8·84 per cent. of copper. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 259.

457. Result of heating one equivalent of copper sulphide and two of lead.

400 grains of copper sulphide were fused with 1,040 grains of lead, and the button of metal produced weighed 1,019 grains, containing 6·76 per cent. of copper. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 259.

458. Result of heating one equivalent of copper sulphide and one of tin.

1,000 grains of copper sulphide were fused with 741·7 grains of tin in powder. They were placed in a luted pot and heated to bright redness for 10 minutes. The product is a grey regulus containing tin, and a white metallic button having the composition, tin 65·17, copper 33·25, sulphur 0·37 per cent. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 259.

459. Result of heating one equivalent of copper sulphide and one of antimony.

160 grains of copper sulphide and 258 grains of antimony were fused together, and produced a regulus containing 57·48 per cent. of copper, and a metallic button like antimony, containing 19·2 per cent. of copper. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 260.

460. Result of heating three equivalents of copper sulphide and one of antimony.

240 grains of copper sulphide and 129 grains of antimony were fused together, and produced a regulus containing 57·9 per cent. of copper, and a button of metal containing copper 33·40, antimony 60·56, and sulphur 6·04 per cent. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 260.

461. Result of heating three equivalents of copper with one of tersulphide of antimony.

192 grains of copper wire in small pieces were fused with 354 grains of tersulphide of antimony at a bright red heat for half an hour in a luted crucible. The product is regulus and metal, of which the former contains 47·53 per cent. and the latter 3·86 per cent. of copper. Experiment by W. Baker. *See* Percy's Metallurgy, 1861, p. 260.

462. Result of heating six equivalents of copper with one of tersulphide of antimony.

380 grains of copper were fused with 354 grains of antimony tersulphide, and produced a regulus containing 66·44 per cent., and a button of metal containing 42·54 per cent. of copper. Experiment by W. Baker. *See* Percy's Metallurgy, 1861, p. 261.

463. Result of heating 12 equivalents of copper with one of tersulphide of antimony.

761 grains of copper were fused with 354 grains of antimony tersulphide, and produced a regulus containing 75·9 per cent., and a button of metal containing 66·72 per cent. of copper. Experiment by W. Baker. *See* Percy's Metallurgy, 1861, p. 261.

464. Result of heating 18 equivalents of copper with one of tersulphide of antimony.

1,141 grains of copper were fused with 354 grains of antimony tersulphide, and produced a regulus containing 77·36 per cent., and a button of metal containing 75·90 per cent. of copper. Experiment by W. Baker. *See* Percy's Metallurgy, 1861, p. 261.

465. Result of heating bisulphide of copper with 25 times its weight of litharge.

100 grains of copper sulphide were fused with 2,500 grains of oxide of lead, and produced a button of metal resembling lead, weighing 422 grains, and 21·67 grains of copper adhering as a film to the surface of the button. This amount of litharge is therefore more than enough to oxidise all the sulphur. Experiment by W. Baker, 1854. *See* Percy's Metallurgy, 1861, p. 262.

466. Result of heating three equivalents of copper with one of tersulphide of antimony.

190 grains of copper were heated with 354 grains of tersulphide of antimony, and the result as seen was a button of metal containing antimony 95·97, copper 3·86, sulphur 0·17, and a regulus containing copper 47·53, antimony 29·32, sulphur 23·15. Experiment by Ambrose Tween. *See* Percy's Metallurgy, 1861, p. 260.

467. Result of heating one equivalent of silver sulphide with two of cupric oxide.

A button of copper and silver is produced.

468. Artificial oxychloride of copper.

Strips of copper foil were put into a wide-mouthed bottle and kept moistened with strong hydrochloric acid, diluted with its own volume of water. The bottle was closed with a loose fitting cork, kept in a warm place and shaken from time to time. This oxychloride was thus produced. Analysed by R. Smith.

Copper - - - -	59·24
Chlorine - - - -	16·87
Oxygen - - - -	11·15
Water by difference - - -	12·74
	100·00

Corresponding to the formula $CuCl_2$, 3 CuO, 3 H_2O. *See* Percy's Metallurgy, Silver and Gold, p. 78.

469. Experimental liquation of lead from copper.

Stage 1. By heating the mass to the fusing point of copper and letting it gradually cool? It shows a thick covering of copper on the surface of the lead.

470. Experimental liquation of lead from copper.

Stage 2. It shows a thin covering of copper on the surface of the lead.

471. Liquated copper and liquation cake.

The copper contained 2·2 per cent. of silver, and was melted with three parts of common lead. Accompanying these is a sample of the grey coating on the surface of the lead and copper alloy.

472. Result of experiment on roasted pyrites with lead.

2,000 grains of roasted pyrites from California, 850 grains of silica, 750 grains of lime, 38 grains of charcoal, and 500 grains of lead were melted together. The result consists of a small non-sectile metallic button floating in a large sectile button, the whole being covered by a green glassy slag, with white fragments scattered in it irregularly. Experiment by R. Smith.

473. Result of experiment on roasted pyrites and lead.

1,000 grains of roasted pyrites from California were heated with the same weights of silica, lime, charcoal, and lead as in the last experiment. The result is very similar, the non-sectile button is absent. Experiment by R. Smith.

474. Metallic copper as a red-coloured powder, precipitated by heating solutions of copper sulphate and sugar together. Experiment by R. Smith.

475. Copper precipitated by zinc.

From a solution of sulphate of copper, acidulated by hydrochloric acid. Experiment by W. Baker. It is in the form of a black powder.

476. Copper precipitated by iron from a solution of copper sulphate.

As a black powder.

477. Copper prepared from copper scale.

By digesting it in dilute sulphuric acid and washing the residue till free from the copper sulphate formed. A black powder. Experiment by W. Baker.

478. Copper prepared from copper scale by hydrogen.

A copper-coloured powder.

479. Copper containing phosphorus.

Made by heating copper in a mixture of bone ash and charcoal in a charcoal crucible to a white heat for about an hour. Experiment by A. Dick. *See* Percy's Metallurgy, 1861, p. 281. It consists of dark grey globules of various sizes, from a mustard seed downwards.

480. Phosphide of copper obtained by the reduction of copper phosphate by carbon.

860 grains of copper phosphate was heated with 240 grains of charcoal at a strong red heat. A dark grey metallic button weighing 200 grains was obtained. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 280.

481. Phosphide of copper by the reduction of copper phosphate by carbon, starch and carbonate of soda.

1,000 grains of phosphate of copper, 200 grains of charcoal, and 500 grains each of starch and carbonate of soda were heated together at a strong red heat; the resulting carbonaceous mass with metallic globules was again heated with 500 more grains of carbonate of soda, and a dark grey button weighing 210 grains is the result. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 280.

482. Phosphide of copper cast at Chatham.

Employed for copper refining by Weston's process. Accompanied by the small masses of metal that ooze out of the surface during the process; a reddish-grey metallic mass.

483. Result of experiment with copper zinc and sodium in 1858.

200 grains of finely powdered zinc, 200 grains of copper foil cut in pieces, and 200 grains of sodium cut in pieces were heated in 600 grains of silico-fluoride of potassium. The result is a yellowish-white metallic button weighing 268 grains, and a quantity of grey opaque glassy slag.

484. Arsenide of copper.

500 grains of copper, 500 grains of starch, and 1,000 grains each of arsenious acid and carbonate of soda were heated together at a strong red heat. The dark grey crystalline metallic button weighed 760 grains, and was accompanied by a little black slag. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 281.

485. Alloy of silicon and copper. Produced in Cowles' electric furnace.

This has been remelted and cast into an ingot. The silicon in combination has been reduced from pure white sand by means of a strong current of electricity passed from large carbon poles through the mixture. The alloy contains 10·59 per cent. of silicon and 89·41 per cent. of copper. The value of this alloy lies in the combination of great tensile strength with great conductivity. Thus while pure copper requires a breaking weight of 17·78 tons per square inch, in this silicon copper, commonly called silicon bronze, the breaking weight is 28·57 per square inch, while the conductivity is only decreased 4 per cent. A small portion of this added to copper or bronze increases the strength and sharpens the castings.

486. Silicide of copper. Prepared by heating copper with sand and charcoal at a high temperature.

It has a fracture of a little lighter tint than pure copper, and when beaten out shows signs of splitting.

487. Silicide of copper. Cast by Robinson and Cottam, and rolled out at the Royal Gun Factory, Woolwich.

It contains 1·82 per cent. of silicon and has a specific gravity of 8·70. Experiment by A. Dick. *See* Percy's Metallurgy, 1861, p. 282. The rolled ribbon shows no signs whatever of splitting.

488. Silicide of copper, which has been rolled out, reheated in sand and charcoal, and fused under glass.

489. Copper pennies cemented into brass in a crucible.

One of the original pennies is shown with three others that have been subjected to the fumes of zinc in a covered crucible, *i.e.*, to the process of cementation. On their surface and for some depth they have become yellow like brass, but a broken one shows that the centre is still copper.

COPPER ORES.

490. Collection of the various copper ores employed in mixture at Hafod Works, Swansea, in 1848.

No. 1. Copper pyrites, called yellow ore, from Fowey Consols, Cornwall, used particularly for making "tile copper." No. 2. Copper pyrites, from Wheal Friendship, Devonshire, yielding about 10 per cent. copper, a green earthy mass. No. 3. Cobre ore, a dark green earth, chiefly pyrites, from Cuba, containing 28¼ per cent. of copper. No. 4. Cobre dust, a dark greenish pyrites in fragments, from the same mine, containing about 12 per cent. of copper. No. 5. The cupriferous residue from iron pyrites calcined for sulphuric acid, in large dirty lumps, and known as Irish ore. No. 6. Vitreous copper, in admixture with iron pyrites and hæmatite, from the Levant Mine, Cornwall, a red earthy ore in small fragments. No. 7. Mixture of various ores as prepared for calcining at the Hafod Copper Works. No. 8. Red oxide of copper with blue and green carbonate, from Burra Burra, Australia, in hard coloured lumps. *See* Percy's Metallurgy, 1861, p. 322.

491. Copper pyrites from Wheal Buller Mine, Cornwall.

Rich in fluor-spar. Ground to small size. Communicated by W. Edmonds, Mines Royal, Neath.

492. Copper pyrites, a yellow copper ore from the Bedford United Mine, Devonshire.

Rich in fluor, not so good for copper as Wheal Buller, broken into small pieces. Communicated by W. Edmonds, Mines Royal, Neath.

493. Copper ore occurring in spathic iron ore.

From the Brendon Hills, Luxborough, Somerset. Analysed by R. Smith. The average yields 16·16 per cent. of copper. Communicated by A. G. Lethbridge.

494. Ordinary copper ore from Alderley Edge, Cheshire.

Consists of green carbonate of copper infused in sandstones of Triassic age.

495. Mixture of the blue and green carbonates of copper Alderley Edge, Cheshire.

496. Alderley Edge ore, containing black oxide of copper.

The black oxide is disseminated in isolated grains in the midst of the sandstone, and at the surfaces of the cracks it is redeposited as green carbonate in the form of malachite.

497. Copper precipitated by scrap-iron from hydrochloric acid solution of ore. Alderley Edge Mines, Cheshire.

A brown earthy-looking deposit, containing 10 to 40 ounces of silver per ton.

498. Liquor from which copper is precipitated by scrap-iron, at Pary's Mountain, Anglesey.

The liquor is derived from water which is pumped into the old copper workings and which takes up some of the salts. Communicated by Mr. Askin.

499. Specimen showing the accidental formation of malachite.

Blown sea-sand, containing carbonate of lime in the state of comminuted shells, has come in contact with the roasted residues containing sulphate of copper, water also being present, the result being the cementation of the particles by green carbonate of copper. At the Arsenic Works, Hayle, Cornwall.

500. Ochre produced in the copper cementation pits in the Mona Mine, Pary's Mountain, Anglesey.

The liquor from which the copper has been precipitated is carried away into open basins, where it is oxidised by the atmosphere and deposits the ochre, which still contains about 1 per cent. of copper.

501. Copper-bearing shale used at the Sangershausen Copper Works, Prussian Saxony.

A hard black shale belonging to the Permian series.

502. Compact copper-bearing shale from Sangershausen, Saxony.

It is black, earthy, compressed, and more or less foliated.

503. "Sand ore" and shale from the Copper Works of Sangershausen, Saxony.

Contains two layers, one richer and more siliceous than the other. 56·08 per cent. is soluble in nitric acid. *See* Percy's Metallurgy, 1861, p. 414.

504. Rich band of copper shale from Sangershausen, Saxony.

A dark compressed shale of high specific gravity.

505. Brecciated band of copper shale from Sangershausen, Saxony.

506. Copper shale, showing richer vein of copper ore, from Sangershausen, Saxony.

It is a shale in two parts, one half being black and the other lighter brown.

507. The layer of copper-bearing shale, known as "Noberge," at Sangershausen, Saxony.

44·58 per cent. is soluble in hydrochloric acid. It is extra hard and compact, as though it were gritty. *See* Percy's Metallurgy, 1861, p. 414.

508. The band of copper ore known as "Oberberge," at Sangershausen, Saxony.

It is a compact mass with no visible stratification, from 4 inches to 6 inches thick; 64·68 per cent. is soluble in hydrochloric acid. *See* Percy's Metallurgy, 1861, p. 415.

509. Massive ore, from Sangershausen, Saxony.

Showing the whole thickness of the band (Abbruch), which is about 1½ inches, and is not laminated like the shales.

The whole of these ores belong to the "Kupferschiefer" portion of the Permian rocks.

510. Copper ore from the Garonne.

Shipped at Bordeaux and used at the Llanelly Copper Works; contains about 9½ per cent. of copper and 8½ ozs. of silver per ton. A quartzose rock impregnated with blue carbonate of copper. Communicated by Verill, Druce, and Co.

511. Eight varieties of copper ore from the Rio Tinto Mines, Spain.

No. 1 is a solid dark pyrites. No. 2 is very similar. No. 3 is a shale with disseminated pyrites. No. 4 is a compact dark pyrites. No. 5 is a massive golden pyrites weathering green. No. 6 is a dark earthy rock with green impregnations. No. 7 is a grit impregnated with copper pyrites. No. 8 is massive iridescent copper pyrites.

512. Prepared copper ore from the Rio Tinto Mines.

513. Spanish copper ore. Portions rejected.

It still contains copper and silver. Communicated by Bertrand de Lis.

514. Cupriferous pig iron.

Found in a cargo of ore from Almeria, Spain; contains 17 per cent. of copper. It is brown and full of holes like a scoria. Communicated by W. Pearce.

515. Goldkrone copper slate.

A black gritty slab. Probably the Permian Kupferschiefer, as at Sangershausen.

516. Cupriferous sandstone from Schweinkopf.

Similar in character to the sandstones of Alderley Edge, containing nests of blue carbonate and bands of green carbonate of copper.

517. Copper ore from Corsica.

Said to occur in a dyke of serpentine similar to that at Monte Catani, in Tuscany. From the French Department of the Exhibition of 1862. Consists of grey copper ore, mixed with copper pyrites.

518. Copper ore from Fronteriza Mine, Spain.

Principally copper pyrites. Communicated by Yglesias and Co., 1874.

519. German copper ore.

A compact copper pyrites.

520. Copper slate for the neighbourhood of Mansfeld, Saxony.

This is the Permian Kupferschiefer, and is said to contain silver and bismuth. It is a soft black shale. Obtained from Mr. Krantz.

521. Rough plate. Copper shale from near Mansfeld, Saxony.

A soft black shale used at the copper works at Hettstedt. Obtained from Mr. Krantz.

522. Copper ore from Mansfeld, Saxony.

A sandstone impregnated with copper salts.

523. Copper ore from Algeria.

A copper pyrites containing 24 per cent. of copper. Analysed by R. Smith.

524. Copper ore from Turkey.

A copper pyrites from Cabbae Tippa, Ordou Mines, containing 27·44 per cent. of copper. Analysed by R. Smith. Communicated by E. Maurice Ward.

525. Native copper from Japan.

It has been melted, and is accompanied by fragments of iron pyrites from the same spot. Communicated by Mr. Bristow.

526. Copper ore from Australia. Queensland ?

Sent by R. Daintree, 1868, a kind of loose earthy gossan.

527. Copper ore from the Bell Mine, Buth, Montana, U.S.A.

Vitreous ore containing silver and iron. Communicated by "W. A. C."

528. Copper ore from Lexington Mine, Buth, Montana, U.S.A.

Vitreous and pyrites ores mixed. Communicated by "W. A. C."

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529. Copper ore from Lexington Mine, Buth, Montana, U.S.A.

Copper and iron pyrites. Communicated by "W. A. C."

530. Argentiferous copper ore from Anaconda Mine, Montana, U.S.A.

Contains 55 per cent. of copper, and 22 ounces of silver to the ton. Imported to Llanelly for smelting. Communicated by Nevill, Druce, and Company, 1883.

531. Copper pyrites from Newfoundland.

Used at the Mines Royal Smelting Works, South Wales, 1869.

532. Precipitated copper from the Cobre Mines, Cuba.

From water rich in sulphate of copper. A solid mass of red copper with a crystalline mammillated surface.

533. Sulphide of copper from Greenland.

Black and crystalline in a brecciated quartz rock. Communicated by Sir W. C. Treveleyan.

534. Copper pyrites from California.

535. Copper pyrites called "Magistral" from Mexico.

Said to be of good quality, but is mixed with gangue.

536. Atacamite from the province of Atacama, Chili.

A hydrated oxychloride of copper found in the form of a bright green sand, yielding 70 per cent. of copper oxide on calcining. A considerable quantity has been imported into Swansea. *See* Percy's Metallurgy, 1861, p. 312. Communicated by R. Pearce.

537. Chilian copper ore containing oxychloride of copper.

A gravelly ore from which, when thrown into the furnaces at Swansea, the chlorine escaped in great quantities. This was highly injurious to the workmen, and at the same time carried off a portion of the copper. Communicated by W. Edmonds, Mines Royal, Neath, 1872.

538. Native copper from the Vista-Bella Mine, province of Cayabamba, Peru.

In the form of a brown earthy-looking aggregated dust.

PRODUCTS OF ENGLISH COPPER SMELTING.

EARLY STAGES.

539. Calcined ore from the Hafod Iron Works, 1848.

Being the result of the first process to which the mixed ores are subjected. *See* Percy's Metallurgy, 1861, p. 322.

540. Calcined ore from the Mines Royal Copper Works.

Also crushed into dust and fragments. Communicated by W. Edmonds.

541. Calcined artificial sulphide of copper.

In the form of a black powder.

542. Cupriferous iron pyrites from Spain, after roasting.

It is practically washed copper precipitated by iron. Communicated by Mr. Pethered.

543. "Ore furnace regulus," Mines Royal Copper Works, 1869.

The result of the second operation. A dark pyritous-looking mass.

544. "Coarse metal" from the Spitty Works, Loughor, near Swansea.

In this state the salt cake is added and rabbled in Napier's process. *See* Percy's Metallurgy, 1861, p. 382. It is granular and pyritous, with a more compact metallic layer on the surface.

545. "Coarse metal" before granulation from Mines Royal Copper Works, Neath.

Poured out in a molten state. *See* Percy's Metallurgy, 1861, p. 324.

546. "Coarse metal" from the Hafod Copper Works, Swansea, 1848.

The final result of the second operation as described in Percy's Metallurgy, 1861, p. 324. Contains about 33 per cent. of copper. A pyritous banded slightly scoriaceous mass.

547. Granulated "coarse metal" from the Hafod Copper Works.

Consists of small brown fragments.

548. Calcined coarse metal from the Hafod Copper Works.

Brown earthy-looking fragments, the result of the third operation in copper smelting (in 1848) as described in Percy's Metallurgy, 1861, p. 324.

549. Calcined granulated metal from the Mines Royal Copper Works, Neath.

Small black fragments. Communicated by W. Edmonds.

550. Calcined coarse metal from the Spitty Works at Loughor, near Swansea, 1848.

The result of the third operation in Napier's process. It contains about 45 per cent. of oxide of copper, and 52 per cent. of the mixed oxides of iron. Loose black earth with larger fragments. *See* Percy's Metallurgy, 1861, p. 384.

551. " White metal " from the Hafod Copper Works.

The result of the fourth operation in copper smelting at these works. It contains 72 per cent. of copper combined with sulphur, and very little iron. *See* Percy's Metallurgy, 1861, pp. 324, 347. It is a dark grey sub-metallic mass tarnishing black.

552. "White metal" which has crystallised in arborescent forms on the surface of a drusy cavity.

It is solid below like the last. Communicated by R. Pearce.

553. Spectacle furnace regulus from the Boston Copper Works.

White metal with large cavities.

554. Furnace metal with a little regulus on the surface.

The produce of washed sweepings of the floors and ground cinders from casting furnaces. Exposed to intense heat for eight hours. Communicated by C. Clifford.

555. Precipitate from "Rio Tinto"; furnace-dried and ready for smelting.

Loose black earth with aggregated lumps.

556. Chilian copper regulus, imported into Swansea in 1865.

For the method by which this regulus is produced in Chili from the mixed copper ores of the country see Percy's Metallurgy, 1861, p. 331. It is a blue-grey, dark weathering solid mass in several crystalline layers. Communicated by Mr. Barth.

557. Close regule (from Chilian ores) obtained at Nevill and Company's Copper Works, Llanelly, 1859.

A black rough mass with vertical cavities lined with moss-copper.

558. Four specimens of rich Chilian regulus, imported into Liverpool in 1880.

A solid regulus with cavities and vertical tubes often having moss-copper disseminated through them. *See* Percy's Metallurgy, 1861, p. 322. Communicated by W. Weston.

559. Regulus from the first fusion of Chilian regulus.

As calcined and fused at the Sutton Copper Works in 1871. It has a brown pyritous aspect and coarse fracture, and is much richer in copper than common "coarse metal."

560. Regulus from the second fusion of Chilian regulus.

Usually called "white metal." The Chilian regulus calcined and fused with rich sulphides and carbonate of copper at the Sutton Copper Works, 1871. The sample is highly crystalline, and from its colour it probably contains iron, and is more properly "blue metal." It has moss-copper scattered over its crystalline surface.

561. "Blue metal" of characteristic colour.

From the Hafod Works, 1861. The result of the fourth operation when there is too much iron in it. *See* Percy's Metallurgy, 1861, p. 349. A dark pyritous mass with a well-marked blue tarnish. Communicated by Mr. Hussey Vivian.

562. "Blue metal" from Hafod Copper Works, Swansea, 1848.

Very massive and dark. Contains about 50 per cent. of copper.

563. Coarse metal (blue) from the Mines Royal, Neath.

Resulting from the fusion of calcined coarse metal. A compact mass in two bands with transverse crystallisation and intervening cavities. Communicated by W. Edmonds.

564. "Blue metal" from the Mines Royal Copper Works, 1869.

The end of a tongue of metal.

565. "Blue metal" from Bankart's Copper Works, Neath, 1859.

Massive and sub-metallic, showing a fine blue-purple colour on fractured surface.

566. "Blue metal" from Keates' furnaces, Bagillt, Holywell, 1867.

Of a mixed blue and brown colour and of hackly fracture, resulting from the smelting together of cupriferous iron-pyrites; the residue from soda works and pyritous ores of copper. Communicated by J. H. Henry.

EXPERIMENTS ON BLUE METAL.

567. Result of experiment on "blue metal" cooled rapidly.

The blue metal, with finely diffused particles of copper, was melted under charcoal in a very small covered clay crucible at a bright red heat, and the crucible immediately on being withdrawn from the furnace was plunged red-hot into cold water. The colour of the surface is copper red, produced by fine particles. *See* Percy's Metallurgy, 1861, p. 352, Experiment 1.

568. Result of experiment on "blue metal" cooled slowly.

The blue metal was melted under charcoal in a very small covered clay crucible at a bright red heat, and the crucible left to cool in the air. The copper is found radiating in gas cavities on the outside of the cooled metal. *See* Percy's Metallurgy, 1861, p. 352, Experiment 2.

569. Result of experiment on "blue metal" cooled very slowly.

The blue metal was melted in a covered clay crucible, placed in another crucible, and surrounded with anthracite powder. Fusion was effected at a bright red heat, and the whole left to cool until the following morning. The copper is seen coating the cavities irregularly. *See* Percy's Metallurgy, 1861, p. 353, Experiment 3.

570. Result of experiment on imitation blue metal.

Disulphide of copper, prepared by heating together "best selected" copper and sulphur, was mixed by trituration with sulphide of iron, containing 29·9 per cent. of sulphur, and prepared by heating thin sheet-iron and sulphur together in the proportions of 7 to 3. Of this mixture 600 grains were triturated with 120 grains of powder of copper, obtained by reducing oxide of copper in a current of hydrogen, and heated to bright redness in a covered clay crucible, contained with another covered crucible, the space between the two being entirely filled with anthracite powder. Copper appears disseminated in the mass in a filamentous form, and especially in a contraction cavity in the centre. *See* Percy's Metallurgy, 1861, p. 353, Experiment 4.

571. Result of another experiment on imitation blue metal.

500 grains of the same mixture were triturated and melted with 50 grains of powder of copper. The resulting metal has copper uniformly disseminated in small particles, but no button is formed. *See* Percy's Metallurgy, 1861, p. 354, Experiment 5.

572. Result of another experiment on imitation blue metal.

500 grains of the same mixture were heated without the addition of any metallic copper. The resulting metal is very like the result of Experiment 5, and *appears* to have as much disseminated copper. *See* Percy's Metallurgy, 1861, p. 354, Experiment 6.

573. Result of another experiment on imitation blue metal.

250 grains of the same mixture were heated with 250 grains of disulphide of copper in a clay crucible, enclosed in another, containing anthracite powder. The metal is studded with copper particles, but no shots of metallic copper are formed. *See* Percy's Metallurgy, 1861, Experiment 7.

574. Result of another experiment on imitation blue metal.

The same mixture was triturated with a large excess of sulphur, and heated in a covered clay crucible in a muffle without any protecting outer crucible. The metal is crystallised in the cavities, and is of two colours, the colour being due to copper microscopically disseminated throughout. *See* Percy's Metallurgy, 1861, p. 354, Experiment 8.

575. Result of another experiment on imitation blue metal.

A mixture of 300 grains of disulphide of copper, and 136 of iron pyrites from South Wheal Frances, was heated in a closed crucible, enclosed within another, filled with anthracite powder. The metal resulting has a coppery hue, which is due to microscopic particles of disseminated copper. *See* Percy's Metallurgy, 1861, p. 354, Experiment 9.

576. Result of another experiment relating to blue metal.

Some disulphide of copper was heated alone in the same manner as in the last experiment. There are cavities on the outer surface, containing angular, apparently crystallised, copper-like particles. *See* Percy's Metallurgy, 1861, p. 355, Experiment 10.

577. Result of another experiment relating to blue metal.

Some of the same disulphide was heated as before with a large excess of sulphur. The metal has a smooth fracture, and copper particles are only seen on the surface, and in a central cavity. *See* Percy's Metallurgy, 1861, p. 355, Experiment 11.

PRODUCTS RICH IN COPPER.

578. "Pimple copper," from Hafod Copper Works, Swansea, 1848.

A dark pyritous mass, showing well the volcano-like eruptions on the surface due to the escape of gas. It is occasionally got in the fourth operation, and is intermediate between white metal and blister copper. It contains about 75 per cent. of copper. *See* Percy's Metallurgy, 1861, p. 362.

579. Pimple copper, from Hafod Copper Works, Swansea, 1848.

A mass consisting of scoreaceous red copper, very much blistered on the surface. Entirely different in appearance from the last.

580. Blister copper, Hafod Works, Swansea, 1848.

The result of the fifth operation, or roasting, in the process of copper smelting, contains about 95 per cent. of copper. *See* Percy's Metallurgy, 1861, p. 324. It has large cavities, and is rough and irregular below.

581. Copper rain thrown off from blister copper.

A mixture of fine and coarse metallic globules, formed in running from the roaster-furnace into the sand bed. Mines Royal Copper Works, near Neath, 1869. *See* Percy's Metallurgy, 1861, p. 410. Communicated by W. Edmonds.

582. Moderately coarse "copper rain."

Produced as above. *See* Percy's Metallurgy, Copper, p. 410.

583. Fine "copper rain."

584. Regule of first running down in the process of making "best selected" copper.

From the Mines Royal Copper Works. *See* Percy's Metallurgy, 1861, p. 330. A coarse scoriaceous mass, consisting mostly of copper. Communicated by W. Edmonds.

585. "Fine metal," resulting from the second fusion of coarse metal.

From the Mines Royal Copper Works, Neath. In the process of making "best selected" copper. A dark, massive sub-pyritous mass, with a few large cavities. Communicated by W. Edmonds.

586. Regule from the second fusion in making best selected copper.

A finely scoriaceous dark mass, mammillated on the surface, and weathering green and copper-red. Communicated by W. Edmonds, Mines Royal, Neath.

587. "Fine metal," named "close regule," in making best selected copper.

See Percy's Metallurgy, 1861, p. 331. A dark grey rough mass, with vertical holes.

588. Copper from under the pigs of regule in the first running down in making best selected copper, at Mines Royal Copper Works.

A small metallic cake, with a cavernous surface. Communicated by W. Edmonds.

589. "Regule," containing 75 per cent. of copper.

Obtained in preparing "best selected" copper, and containing the purer parts of the metal. Hafod Copper Works, Swansea. It has a dark rough fracture, with a central cavernous band and vertical holes filled with moss-copper.

590. Specimen illustrating the "best selected" process.

Showing the state or form of the copper when separated in the furnace at or above the melting-point of copper. Hafod Works, Swansea, 1848. It consists of a small flat dark regular nugget of copper with a dark surface.

Ore-furnace and Metal Slags.

591. Ore-furnace slag. Hafod Copper Works, Swansea.

The refuse from the second operation in copper smelting. Compact, black and sub-metallic, with a bluish lustre.

592. Ore-furnace slag, showing a porphyritic appearance.

This is due to the unmelted pieces of quartz. Hafod Works, Swansea, 1848.

593. Ore-furnace slag, showing shots of regulus.

Hafod Works, Swansea, 1885. *See* Percy's Metallurgy, 1861, p. 324. It is a black rough mass, with more brilliant but equally black minute spots here and there, which are the separating regulus.

594. Ore-furnace slag, showing spherulitic arrangement and white patches.

From Hafod Copper Works, Swansea. This form is said to be never seen except when lime in notable quantity is present. The white patches are the unmelted flux; the black radiating spherulites are composed of flat rhombic plates.

595. Crystallised ore-furnace slag, showing spherulitic arrangement.

Hafod Works, Swansea. The spherules have no definite boundary, but are produced by a radiating arrangement of the black plates. Communicated by W. Morgan.

596. Crystallised ore-furnace slag. Hafod Works.

Showing a number of interlocking flat prismatic forms. These are the same plates as in the spherulitic form, but they are not arranged radially. Communicated by W. Morgan.

597. Crystallised ore-furnace slag from Hafod Works.

One specimen shows very fine hair-like crystals arranged in parallel bands, which in the other combine together to form a striated rectangular parallelopiped bevelled on all its edges.

598. Ore-furnace slag with crystals and angular pieces of quartz included.

Morfa Copper Works, Swansea, 1885. The crystals are small and almost buried in the amorphous matrix.

599. Ore-furnace slag from Mines Royal Copper Works.

Not of a good quality, being too fluid when melted. It is light and massive, with a blue and brown tarnish. Communicated by W. Edmonds.

600. Ore slag from first fusion. Mines Royal Copper Works, Neath.

A bluish-grey sub-metallic compact mass, with fragments of the flux imbedded. Communicated by W. Edmonds.

601. Ore-furnace slag used for making a culvert from the copper furnaces.

It has been discoloured on the surface, and was therefore mistaken, when wet, for refinery slag. From the Sutton Copper Works, 1871.

602. Ore-furnace regulus and slag.

From the Mines Royal Copper Works. The regulus is very scaly, and the slag is crystalline.

603. Junction of "metal slag" and regulus.

From the Mines Royal Copper Works, 1869. Showing both results of the fourth operation in copper smelting. The metallic slag is blue-black, compact, and with platy crystals. The regulus is rough, reddish, and filled with moss-copper.

604. "Metal slag" from the fourth operation in copper smelting.

Hafod Works, Swansea, 1865.

605. Metal slag from Hafod Works, 1865, containing in a cavity numerous small octahedral crystals of magnetite of brilliant lustre.

606. Metal slag from the Hafod Copper Works, Swansea.

It has the surface covered with large vertical crystalline plates of brilliant black, each being striated rectangularly parallel to the edges of the plates.

607. Metal-furnace slag from Hafod Copper Works, Swansea.

This has close plates which are aggregated in parallel sheaves, and the intervals are spotted with small hexagonal scales, as in the refinery slags of the iron puddling furnaces.

608. Metal slag, probably from Copper Works.

Communicated by R. Phillips. The surface is covered by thin vertical black plates, each with numerous rectangular ridges.

609. Crystallised surface of metal slag. Swansea, 1869.

Consisting of interlocking flat crystalline plates, on whose surface are innumerable octahedral points with brassy lustre, probably of copper sulphide.

610. Crystallised metal slag from the Hafod Works, Swansea.

Showing arborescent crystals in rectangular groups; brown, with a purple lustre. Communicated by W. Morgan.

611. Crystals in a metal slag. Swansea, 1883.

They are very brilliant, rhombic-hopper shaped, and probably consist of a silicate of iron.

612. Copper slag from old smelting works at Middleton Tyas, Yorkshire.

Black and compact, and full of bright acicular crystals. Communicated by W. Weston.

613. Ore-furnace slag from Whiston Copper Works, Cheadle, Stafford.

This slag, in acicular crystals of a dark colour, arranged in bundles perpendicular to the surface, was produced in 1849, when the Ecton and other ores were smelted, containing carbonate of copper. Communicated by J. Keates.

614. "Sharp slag" from second fusion. Mines Royal Works.

Produced in the third method of smelting by the second fusion of the coarse metal and other ingredients. *See* Percy's Metallurgy, 1861, p. 329. A blue tarnishing crystalline mass. Communicated by W. Edmonds.

615. Crystallised sharp slag from second fusion. Mines Royal.

Consists of brilliant intersecting thin rhombic plates, often arranged so as to produce a hollow crystalline form on the surface of a thin sheet of black slag. Communicated by W. Edmonds.

616. Crystallised sharp slag from second fusion.

From the Mines Royal Copper Works, 1859. Minute octahedral crystals of black magnetite (?) occupying flat cavities in the blue-black slag. Communicated by W. Edmonds.

617. Fine metal slag.

The result of the third fusion in the modified process of copper smelting. A compact reddish-yellow inch-thick slab with a flat cavity coated with low rectangular pyramids of silicate of iron (?). Communicated by W. Edmonds.

618. Roaster slag from the Hafod Works, Swansea.

The result of the last processes in the modified form of copper smelting. It contains copper disseminated in blebs. *See* Percy's Metallurgy, 1861, p. 329. A very scoriaceous mass.

619. Roaster slag from the Mines Royal Copper Works, Neath.

A rough fractured minutely scoriaceous dark mass, containing metallic copper disseminated in fine grains. Communicated by W. Edmonds.

620. Old copper slag from the Swansea district.

Weatherworn and coated with carbonate of copper.

621. Slag from a cupola working first slags with limestones at Detroit Copper Works.

An opaque black glass.

SPECIAL FURNACE PRODUCTS.

622. Scum from the tapping pit of an ore furnace. Swansea.

A fine loose greenish powder. Principally composed of sulphur.

623. Deposit from the ore-furnace flues. Hafod Works, Swansea, 1848.

A light brown loose dust aggregating into lumps.

624. Crystals in an ore-furnace bottom. Mines Royal, Neath, 1860.

They are brilliant octahedra (? of magnetic oxide), with an efflorescence or capillary metallic copper. *See* Percy's Metallurgy, 1861, p. 334. Communicated by W. Edmonds.

625. Crystals in an ore-furnace slag, at Morfa Copper Works, Swansea, 1886.

They show a radiate form, possibly a silicate of iron, and are thought to be a form of augite. Communicated by Mr. Terrill.

626. Deposit coating the bricks inside the stack of the ore-furnace at the Mines Royal Works, Neath.

A green scoriaceous earth containing carbonate of copper. Communicated by W. Edmonds.

627. Deposit coating the bricks inside the stack of the ore-furnace at Mines Royal, after it has been fused.

It is now a blue-green semi-vitreous mass. Communicated by W. Edmonds.

628. Dinas clay from the ore-furnace at the Mines Royal Works, Neath, showing partial fusion.

There are two specimens, one from the bottom, the other used for repairing the furnace; both are black glass with confused angular inclusions of quartz. Communicated by W. Edmonds.

629. Bed of metal furnace when making metal containing about 40 per cent. of copper. Morfa Copper Works, Swansea, 1883.

Contains crystals referred to bornite, or copper sulphide. It is in small rhombic dodecahedra of dull lustre. Communicated by Mr. Terrill.

630. Pieces from furnace bottoms. Morfa Copper Works, 1885.

One shows a stalactitic form, the rest are mixed earthy masses.

631. Clay from the bottom of a copper furnace, showing artificial copper pyrites by infiltration.

Morfa Copper Works, 1871.

632. Furnace product resulting from the melting of a roast heap of yellow sulphide of copper.

Within it is still the yellow copper pyrites, but the surface is clothed with small brilliant blue-black crystals of the form of octahedra. Communicated by Josiah Cooke.

633. Brick from a copper refinery furnace bottom, at the Morfa Copper Works, Swansea.

The brick is white and softened, and smells strongly of sulphur. The outside is deeply impregnated with blue crystalline sulphate of copper. Communicated by Mr. Terrill.

634. Artificial felspar from the furnace of the Sangershausen Copper Works.

These are transparent purple-tinted prismatic combinations of the triclinic system, and occur coating the surface of a black crystalline regulus.

635. Artificial felspar from the furnace of the Sangershausen Copper Works.

These are semi-transparent white, small prismatic combinations of the triclinic system, some of which show twining.

Samples of these artificial felspars have been analysed by Heine and Abich. One analysis gives silica 65·95, alumina 18·50, ferric oxide 0·68, lime 4·28, soda 10·47 per cent., which approaches nearest to some examples of oligoclase.

636. Artificial felspar from the furnace of the Sangershausen Copper Works.

These are black lustrous oblique rhombic crystals, almost fibrous in parts. An artificial felspar has been analysed by Rammelsberg from Laimbach in this district, and has yielded silica 63·96 per cent., ferric oxide 20·04, potash 15·26, lime 0·43 per cent., in other words, it is in an iron orthoclase free from alumina.

637. Bed of natural ochre from the Mona Mine, Anglesey.

This is originally derived from cupriferous ores, but is now free from copper which has been precipitated. Obtained in 1867.

638. Skeleton crystals from metal slag. Hafod Works, Swansea.

They are composed of numerous octahedra, and appear to consist of magnetite. Communicated by W. Morgan.

639. Mass of cuprous oxide found in a furnace bottom, coating a piece of copper.

From the Greenfield Copper Works at Holywell, 1867. It shows the characteristic red colour in thin pieces. Communicated by Mr. Hughes.

640. Copper found occasionally under the pigs of pimple metal in the third fusion. Mines Royal, Neath.

A thin brassy coloured scoriaceous mass, containing much tin. Communicated by W. Edmonds.

641. Hæmatite crystals in slag, from melting precipitate with coal and lime.

Morfa Copper Works, 1884. They are noticed in the Mineralogical Magazine, 1884, and consist of thin interosculating black plates. Communicated by Mr. Terrill, 1884.

642. Cupreous oxide from a furnace bottom at the Sutton Copper Works, Liverpool, 1848.

It consists of a thin slab of regulus, the centre of which is occupied by metallic lustred, ruby-red translucent crystals, like ruby copper. Communicated by J. Keates, Jr.

643. Crystallised cupreous oxide from a furnace bottom at the Morfa Works, Swansea, 1885.

In modified octahedral forms. Communicated by Mr. Terrill.

644. Crystallised cupreous oxide from slag at Morfa Copper Works, 1883, produced in melting precipitate.

Crystals so minute as to form a reddish bloom tinged with blue. Communicated by Mr. Terrill.

645. Sand bottom of roaster furnace, showing infiltration of copper. From Mines Royal Copper Works, Neath.

A scoriaceous mass. Communicated by W. Edmonds.

646. Crystalline deposit on the walls at the Copper Works at Mines Royal, Neath, 1869.

A sort of efflorescent form of dark grey dust, compacted into mammillated forms. Slightly soluble. Communicated by W. Edmonds.

647. Globular concretions of copper, formed under a steam jet in a tank. Port Tennant Copper Works, Swansea.

The copper is being precipitated by iron in the tank for the extraction of silver by Augustin's process, and a jet of steam enters at the side to keep the water hot; underneath this jet these globules accumulate. They consist of crystalline particles of precipitated metallic copper, coated over with a sheath of the same, about the thickness of writing paper. Some of the globules have been separated by levigation. Communicated by Jos. Roskell.

648. Crystallised sulphate of lime on mortar joints in walls at Neath Abbey, where exposed to the sulphurous smoke of the Copper Smelting Works, 1869.

This is discoloured to a dirty grey, and closely resembles the last. Communicated by G. Brown.

649. Sulphate of copper from a culvert, which carried off the residual gases from a sulphuric acid chamber and those of some calcining furnaces, and to which water had access. From the Swansea district.

650. Copper fume from a copper furnace flue.

At Mr. Grenfell's Works, Swansea, 1840. A light porous mass, largely charged with green carbonate of copper.

651. Specimen of sand showing the penetrating power of copper.

It has been used as a mould for gun casting at Woolwich, and the metal has now entered its interstices, so that it is very largely impregnated with copper, making it hard and yellow. Communicated by A. Laird, 1860.

652. Sulphate of soda and copper, from Widnes Metal Works, 1871.

A compact green crystalline mass.

653. Lining of the ore-furnace stack at Mines Royal Copper Works, 1869.

A light cavernous slab, showing the deposit of copper fume, principally by the blue coloration of the exposed half.

654. Samples illustrative of the elimination of arsenic from copper.

Three of these show the junction of the roaster slag of blister copper with the sand-bed of the furnace, and where it becomes intermingled with this, the action of the sand liberates the arsenic acid, which is in combination with the copper as arseniate, and this is decomposed into arsenious acid and oxygen. The fourth consists of arsenious acid collected from the sand round the pigs of slag, which is whitened all around by it. The fifth is the pimple copper, topped after drawing off this slag, and from which a large part of the arsenic formerly present has been removed, so that while the slag contains 10·41 per cent. of arsenic, the copper contains only 4 per cent. Communicated by D. Watson, Broughton Copper Works, Manchester, 1883.

655. Crystals of arsenious acid in slag.

Produced in the process of making "best selected" copper at Hafod Works.

There are two sets of specimens. In the flat pieces the slag is black and rough, and contains moss-copper. The crystals consist of small transparent octahedra, scattered over the depressions in the cavities. Communicated by W. Morgan, 1848. The other specimen was brought from the same works by R. Smith, and shows large octahedra in a cylindrical (artificial) cavity.

656. Crystals of arsenious acid covering the surface of a slag.

The slag is very thin, and many of the crystals are twined. Communicated by A. Primrose.

657. Crystals of arseniate of copper formed in a furnace bottom on a metal slag.

From Morfa Copper Works, 1885. They are of a beautiful emerald-green colour. Communicated by W. Terrill.

658. Crystals (? arsenical) in copper slag, Swansea.

Transparent crystals in radiating plates of rhombic hexagonal form, tinged with an orange colour. Communicated by Mr. Benson.

659. Crystalline bright black needles forming on the surface of malleable copper.

From Swansea. Communicated by J. Benson.

Moss Copper.

660. Large specimen of moss copper on white metal.

The copper is in very long hairs, and has been oxidised to a black colour by exposure.

661. Regulus showing minute fibres of metallic copper in crevices. 1848.

The moss copper is chiefly confined to the surface. Communicated by A. Parkes, Birmingham.

662. Moss copper in rather thick strings in cavities, and on the surface of an ore-furnace regulus.

From Verrill and Co.'s Works, Swansea, 1869.

663. Moss copper in cavities in a regulus.

In this specimen the cavities are long and parallel gas-paths through the regulus, and the copper is deposited in radial strings from the sides of these cavities. Communicated by W. Weston.

664. Specimen showing moss copper outside and inside the regulus.

The copper on the outside is very dense, arranged perpendicular to the surface and tarnished. That on the inside is perpendicular to the narrow tubes, which are themselves perpendicular to the surface, and it is untarnished.

665. Short fibred moss copper formed in irregular cracks in a regulus.

The fibres of the copper are perpendicular to the surface of the cracks. A. Parkes' Works, Birmingham, 1880.

666. Fibrous copper from a fine metal furnace bottom, Mines Royal, Neath.

This is long in fibre and very yellow in tint, and very loosely and irregularly connected with the stone. Communicated by W. Edmonds.

667. Fibrous copper from a fine metal furnace bottom, Mines Royal, Neath.

This lies in comparatively narrow bands, and the fibres run directly across from one side of the band to the other, and are brilliant copper-red in colour, and very compact. Communicated by W. Edmonds.

668. Fibrous copper from a roaster furnace bottom. Mines Royal, Neath.

This is in parallel-sided bands, across which the fibres run very compactly. The bands are divided into two or more smaller bands alternately of yellowish copper-red, and brilliant purple-red, the latter being the narrower. Fully described in Percy's Metallurgy, 1861, p. 360. Communicated by W. Edmonds.

669. Fibrous copper from a fine metalfurn ace bottom, Mines Royal, Neath.

The copper in this is in very long fibres, which are of several different tints in different parts, from brassy-yellow to purple-red. Communicated by W. Edmonds.

670. Moss copper produced in the white metal, at the Hafod Copper Works, Swansea. Three specimens.

The copper is scattered irregularly in large cavities, the fibres are very fine and of a brilliant red colour. Communicated by W. Edmonds.

671. Hair-like substance resembling moss copper, on the surface of "fine metal." From the Morfa Copper Works, Swansea, 1886.

The fibres are long and hair-like, and seem more elastic than copper. They are brassy in colour, with several surface tints: they are grouped in tufts, but have no sensible connexion with the "metal."

672. Artificial sulphide of copper, showing moss copper in the cavities.

KERNEL ROASTING.

673. Illustrations of kernel roasting.

A collection of samples of cupriferous iron pyrites which have been roasted so as to concentrate the copper in a kernel in the centre, whence it is smelted, and the residue is lixiviated to extract sulphate of copper, and by Claudet's process for silver. From Widnes Metal Works. *See* Percy's Metallurgy, 1861, p. 439, *et seq.*

674. Rich specimens of kernel roasted cupriferous pyrites.

From Widnes Metal Works, 1871. The kernels contain about 15 per cent. of copper. Communicated by J. A. Phillips, 1871.

675. Iron pyrites, containing 2·18 per cent. of copper, subjected to kernel roasting in Spain.

The kernels used to be thrown away, and the residue only treated with water for sulphate of copper. 1858.

PRODUCTS OF THE REFINERY FURNACE.

REFINERY SLAGS.

676. "Refinery slag" from Sutton Copper Works, St. Helen's, Lancashire, 1871.

The last material separated from the marketable copper in the refining process. *See* Percy's Metallurgy, 1861, p. 325. It is compact and sub-vitreous, slightly scoriaceous on the top, and shows two colours, orange and red.

677. Refinery slag from the Mines Royal Copper Works, Neath.

A sub-vitreous red mass, with large cavities. Communicated by W. Edmonds.

678. Refinery slag from the Hafod Copper Works, Swansea.

Largely scoriaceous.

679. Slag from refining Chilian bar copper.

This copper assays to 98 per cent. Refined at Greenfield Copper Works, Holywell, 1871. The slag is very compact, dark reddish in colour, slightly crystalline, and very finely scoriaceous.

680. Refinery slag from Detroit Copper Works.

Remarkably red and sub-vitreous.

SPECIAL REFINERY PRODUCTS.

681. Stalactite from under the arch of a refinery furnace, Mines Royal Copper Works, 1859.

It is composed of tubes of metallic copper, and a mass resembling white metal, forming numerous mammillated processes growing out from the sides. Communicated by W. Edmonds.

682. Dinas brick from the roof of a refinery, Mines Royal Copper Works.

Showing the corrosive action of cuprous oxide, which has converted it into a purple scoriaceous slag.

683. Portion of refinery furnace bottom, showing absorption of copper, Mines Royal Copper Works.

It is converted into the appearance of a porous refinery slag. Communicated by W. Edmonds.

684. Portion of refinery furnace bottom, Mines Royal.

It is coated with a brilliant sealing-wax coloured band of refinery slag. Communicated by W. Edmonds.

685. Bottom of a refinery furnace, Mines Royal, 1870.

In use six years; is now a very fine semi-vitreous scoriaceous slag of the colour of refinery slag.

686. Refinery furnace bottom, Mines Royal, 1869.

Very like the last, but heavier and more copper coloured.

687. Bed of copper refinery furnace, Morfa Works, Swansea, 1883.

Contains small brilliant crystals, some of which resemble octahedra, stated to be compounds of cuprous and cupric oxide in equivalent proportion. Communicated by Mr. Terrill

688. Piece of the bottom of a refinery furnace under repair, Hafod Works, Swansea, 1865.

It is a green, porous, semi-vitreous mass, tinged here and there with blue, probably a silicate of copper, but the original grains of sand are not obliterated.

689. Bed of refinery furnace, containing dark blue crystals. From the Morfa Copper Works, Swansea.

The crystals are insoluble in acids, and contain oxide of copper and silica. They coat the surface of the brick, and also occur massive in the interstices. Communicated by Mr. Terrill, 1883.

690. Globules of copper formed during ebullition of the copper in a refinery furnace, and carried off by the draft. Mines Royal Copper Works, Neath.

They are very minute and dark-coloured, and are partly aggregated together in a solid mass. Communicated by W. Edmonds.

691. Crystals of stannic acid found above the bridge of a copper refinery surface, by Napier's process.

Small brownish-grey acicular crystals, perfectly transparent, after having been treated with aqua regia. They have been examined by Professor Miller, of Cambridge. *See* Percy's Metallurgy, 1861, p. 374.

692. A set of specimens illustrating the process of copper refining, at Mines Royal, Neath, in 1869.

No. 1 is taken from the original blister copper after it had been filled into the refinery furnace, melted and skimmed. The surface of the ingot from which it was taken was very much swollen, and the fracture shows numerous large cavities. No. 2 is taken from the same mass after the second skimming. The ingot has become flat round the edge, though still swollen in the middle, and cavities of some size are still seen in the fracture. No. 3 has been rabbled and poled until the ingot is flat on the surface, and shows a set on the face, which proves it to be ready for the refiner. No. 4 has had the lead put in, and it has been poled up to tough pitch, and is now ready for ladling. No. 5 is the same copper which has been a little overpoled, so that the surface of the ingot is a little "too fine" and "too high." No. 6, a typical sample of overpoled copper, showing the characteristic ridge along the centre of the ingot. No. 7 is copper fairly overpoled, in which condition the charcoal covering over the face of the copper would be removed, and the side door taken down to allow a current of air to pass over its surface to restore its malleability. Communicated by W. Edmonds.

693. A set of specimens illustrating the process of copper refining at the Hafod Works, Swansea.

No. 1. Dry copper, with the characteristic depression on the surface of the ingot. Nos. 2–6 are ingots taken during the process of poling, and show the varieties of fracture and surface indicative of their diminishing amount of dryness. No. 7 is copper at "tough pitch," in which the surface of the copper is remarkably flat. No. 8 is slightly overpoled, the surface of the ingot commencing to rise in the centre. No. 9 is very much overpoled, the central ridge being very conspicuous. With these there is a small piece which has been taken out as a "proof" during the process. *See* Percy's Metallurgy, 1861, p. 325.

ILLUSTRATIONS OF FOREIGN COPPER SMELTING—SAXONY.

694. Ore-furnace slag, "Rohschlacke," from the Sangershausen Copper Works, Prussian Saxony.

See Percy's Metallurgy, 1861, p. 415 (Process 1). This contains less than 0·3 per cent. of copper. A compact flat slab of purple opaque glass.

695. Ore-furnace regulus, "Rohstein," from Sangershausen.

These samples show masses of moss copper. The general analysis of this gives from 40 to 50 per cent. of copper. *See* Percy's Metallurgy, 1861, p. 419. It is black and compact with round cavities.

696. Ore-furnace regulus after the first roasting, "1-feuriger Rohstein," from Sangershausen.

Flat rough fracturing slabs with vertical tubes, weathered and unweathered specimens. Percy's l.c., p. 415 (Process 3).

697. Ore-furnace regulus after the second roasting, "2-feuriger Rohstein," Sangershausen.

A brassy mass with winding cavities.

698. Ore-furnace regulus after the third roasting, "3-feuriger Rohstein," Sangershausen.

An irregular dark scoriaceous mass.

699. Ore-furnace slag, "Rohschlacke," Sangershausen.

See No. **694.** A black irregular slab of glass rock with abundant cavities.

700. Ore-furnace slag, "Rohschlacke," Sangershausen.

Obsidian-like form.

701. Concentrated regulus, "Spurstein," after one roasting, Sangershausen.

See Percy's Metallurgy, 1861, p. 415 (Process 5). Brassy and scoriaceous.

702. Concentrated regulus, "Spurscein," after two roastings, Sangershausen Copper Works.

Heavy and scoriaceous, weathering green.

703. Concentrated regulus, "Spurstein," after three roastings, Sangershausen.

Black scoriaceous and sub-crystalline.

704. Concentrated regulus, "Spurstein," after four roastings, Sangershausen.

Dark crystalline, very open and scoriaceous.

705. Concentrated regulus, "Spurstein," after five roastings, Sangershausen.

Brassy and frothy, dark on the surface.

706. Concentrated regulus, "Spurstein," after six roastings, Sangershausen.

Shows masses of metallic copper in the spongy regulus.

707. Thin rich regulus, "Dünnstein," Sangershausen.

One product of the sixth process or third fusion which contains about 63 per cent. of copper. *See* Percy's l.c., p. 415. Very heavy, about half an inch thick.

708. Black copper, "Schwarz Kupfer," Sangershausen.

The other product of the sixth process. Only has a dark surface in parts, otherwise is red on the surface like the Japanese copper. It is in very thin plates.

709. Refined copper, "Gaar Kupfer," Sangershausen.

In a rectangular ingot; the final result of the process here pursued.

710. Ore-furnace slag, "Rohschlacke," from the Copper Works at Hettstedt near Mansfeld, Saxony.

A black obsidian-like glass.

711. Ore furnace regulus, "Kupferstein," Hettstedt.

Contains 32 per cent. of copper. Heavy, black, sub-crystalline, with occasional cavities.

712. Once roasted ore-furnace regulus, "1-mal geröstete Kupferstein," Hettstedt.

See Percy's Metallurgy, 1861, p. 415. A black compact stony mass, weathering green.

713. Twice roasted ore-furnace regulus, "2-mal geröstete Kupferstein," Hettstedt.

An irregular and brecciated dark rock.

714. Thrice roasted ore-furnace regulus, "3-mal geröstete Kupferstein," Hettstedt.

A black loose cinder-like mass.

715. Furnace product, "Gestübestein," Hettstedt.

Part of this is white, belonging to the furnace wall, the other part is black and shows bright parallel, obliquely radiating crystals.

716. Furnace product, "Gestübestein," Hettstedt.

The floor consisting of rough grit with fragments of charcoal, and impregnated with copper.

717. Sulphurous regulus, "Schwefel," Hettstedt.

A black compact mass with a few holes.

718. Copper sulphate, Hettstedt Copper Works.

In large blue crystals obtained by washing the roastings of the ore-furnace regulus. *See* Percy's l.c., p. 416.

719. Mixed sulphate or "black vitriol," Hettstedt Copper Works.

Dark dirty coloured crystals with a shade of blue, in oblique prisms, obtained in association with the copper sulphate; contains several isomorphous bases. *See* Percy's Metallurgy, 1861, p. 424.

720. Mixed sulphate deposited round roots, Hettstedt Copper Works.

Dirty grey transparent crystals.

721. Concentrated regulus, "Spurstein," Hettstedt Copper Works.

The product of the second fusion. *See* Percy's Metallurgy, 1861, p. 421. Contains 59 per cent. of copper. A flat slab ⅝ inch thick, dark grey sub-metallic, with fine vertical tubes.

722. Fluor-spar used in the first and second fusions at Hettstedt.

723. Metal-furnace slag, "Spurschlacke," Hettstedt.

The other product of the second fusion. An irregular slab with numerous cavities.

724. Once roasted regulus, "1-mal geröstete Spurstein," Hettstedt.

A heavy irregular cinder-like mass.

725. Twice roasted regulus, "2-mal geröstete Spurstein," Hettstedt.

A more open cindery mass with black metallic lustre in places.

726. Thrice roasted regulus, "3-mal geröstete Spurstein," Hettstedt.

A cindery dark mass with specks of copper scattered throughout.

727. Four times roasted regulus, "4-mal geröstete Spurstein," Hettstedt.

Nearly the same as the last.

728. Five times roasted regulus, "5-mal geröstete Spurstein," Hettstedt.

A similar cindery mass of greater specific gravity.

729. Six times roasted regulus, "Gaarrost," Hettstedt.

A sub-metallic cinder of a reddish tint.

730. Black copper, "Schwartz Kupfer," Hettstedt Copper Works.

The product of the third fusion of the roasted regulus, contains 95 per cent. of copper. *See* Percy's Metallurgy, 1861, p. 422. A run-out ⅜ inch thick slab.

731. Thin rich regulus, "Dünnstein," Hettstedt.

A thin black slab, closely set with fine vertical tubes. This is the other product of the third fusion. It contains about 60 per cent. of copper, and is roasted again with the concentrated regulus. *See* Percy's l.c., p. 421.

732. Copper slag, "Schlacke," Mansfeld.

Probably a metal-furnace slag. A thin black compact slab, with a stalactitic under-surface.

733. Residual products, "Gekrätz," Hettstedt.

Used up in the furnaces for melting with the ores. *See* Percy's Metallurgy, 1861, p. 417. An irregular glassy cinder, filled with fragments of charcoal.

734. Cement copper, Hettstedt Copper Works, Mansfeld.

A tangled network of fine strings of metallic copper.

735. Furnace product, "Ofen Glimmer," Mansfeld Copper Works.

Obtained from Dr. Krantz in 1842. Bright black crystalline plates, arranged so as to have empty intervals giving a foliated appearance.

736. Roasted copper ore, Halsbrückner Hütte Copper Works, near Mansfeld.

A coarse reddish-brown powder.

737. Concentrated copper regulus, "Kupferstein," Hettstedt, Mansfeld.

Now coated with green carbonate of copper.

738. Ore-furnace regulus, "Rohstein," Freiberg Copper Works.

Compact purple-brown dust, with gas cavities.

739. Ore-furnace slag, "Rohschlacke," Freiberg.

A thin irregular sub-vitreous slab, with rather large cavities.

740. Roasted ore-furnace regulus, "Geröstete Rohstein," Feiberg.

Reddish earthy cinder, with large cavities.

741. Concentrated regulus, "Kupferstein," Freiberg.

A coarse reddish heavy slab, showing much metallic copper.

742. Roasted concentrated regulus, "Geröstete Kupferstein," Freiberg.

A very irregular dark scoriaceous mass, with large cavities.

743. Thin matt, "Kupferlieh.," Freiberg.

A ¾-inch slab, with numerous vertical tubes.

744. Roasted thin matt, "Geröstete Kupferlieh.," Freiberg.

A sub-metallic dark grey exfoliated mass.

745. "Black copper," Freiberg.

Solid metal, with a coarse fracture and dull colour.

746. Crystals of magnetic iron.

Found in the bed of a reverberatory furnace used for roasting the ore in the copper works of Freiberg. None of these appear to be simple octahedra, but more resemble crystals of the rhombic system; they are iridescent.

747. Ore-furnace regulus, "Rohstein," Muldner Hütte Copper Works, near Freiberg.

The result of the first fusion of the ore. A massive one-inch slab of a rather coppery hue.

748. Ore-furnace slag, "Rohschlacke," Muldner Hütte, Freiberg.

A solid black sub-metallic mass, showing a surface crystallisation in flat rectangular plates. The other product of the first fusion of the ore.

749. Roasted ore-furnace regulus, "Geröstet Rohstein," Muldner Hütte.

Compact brown dust, with numerous cavities (like No. **741**).

750. Metal-furnace regulus, "Kupferstein," Muldner Hütte.

A $\frac{3}{4}$-inch dark slab, with vertical tubes and a green efflorescence of carbonate of copper due to its exposure to the air. The product of the second fusion.

751. Metal-furnace regulus, "Kupferstein," Muldner Hütte.

Brownish, sub-metallic, showing the long cavities perpendicular to the surface lined with moss copper.

752. Concentrated Kupferstein, Muldner Hütte.

A solid pyritous mass, with iridescent colours, principally blue, owing to exposure to the air.

753. Red litharge, "Rothe Glatte," Muldner Hütte.

Produced by cupellation. In thin loose scales mixed with similar white scales.

754. Furnace bottom, "Heerd," Muldner Hütte.

A heavy porous slab, with a greenish-yellow transverse crystallisation of litharge.

755. Crystals of arsenious acid from the roasting heaps on which the ore-furnace regulus has been roasted. Muldner Hütte, Freiberg.

In transparent octahedra contained in the crevices. This is eliminated from the regulus in the process of roasting. *See* Percy's Metallurgy, 1861, p. 432.

756. Crystallised furnace bottom, Muldner Hütte.

A black regulus-like mass, with the surface covered with mammillæ of small cubical crystals.

757. Crystallised slag, Muldner Hütte.

From the concentrated Kupferstein furnace. Showing black semi-transparent thin parallel plates in nests like those of an iron silicate.

758. Sheet copper, Grünthal Hütte.

759. Refined copper, pitch assay, Grünthal Hütte.

A small cake, flat and bent.

760. Melted realgar covering ore-furnace regulus, or Rohstein.

A brilliant red glassy incrustation, from a roast heap at Freiberg; a very rare product from the ore. *See* Percy's Metallurgy, 1861, p. 432.

761. Argentiferous black copper, an accidental product.

A small running of a rather lighter tint than purer copper.

762. Metallic copper in Kupferstein from Halsbrücke.

A black regulus, with scattered metallic grains. Communicated by Mr. Blandford.

763. Porous copper from a refinery, Mansfeld, Saxony.

764. Yellow litharge, called "Scheide Glätte," from the Copper Works of Halsbrückner Hütte.

765. Slag containing vanadium from Eisleben.

This is a blue glassy slab, one inch in thickness, of ore-furnace slag, obtained by treating the copper slates of Saxony. (Two specimens.)

766. Cement copper deposited on old miners' tools.

A porous granular mass, found covering the tools in the old Rammelsberg mine in the Harz, reduced by chemical reaction on the copper-bearing water passing over the iron in the tools. Two eroded tools accompany the copper.

767. Roasted Kupferstein, Clausthal, Harz.

From lead smelting works. Two specimens, one of a 1-inch slab with vertical cavities containing moss copper, the other a thin compact slab. In both there is a sheet of copper on the surface.

768. Copper regulus, with a fibrous band of moss copper.

The band of copper with transverse fibres separates a sub-metallic regulus from a rusty-looking covering. From the Grünthal Saigerhütte, Saxony.

SPECIMENS ILLUSTRATING THE COPPER-SMELTING PROCESSES, including the extraction of silver from it, as pursued at the Rammelsberg smelting works in the Harz, by Breymann, 1840–50.

PRIMARY SMELTING.

Products of the first operation.

769. Sulphur obtained in roasting the sulphide ores of the district, produced in cakes.

770. Once roasted ore.

The mass is partly a sulphide, the roasting not having been completed; the remainder is black and porous, and coated with limonite and sulphur.

771. Twice roasted ore.

A finely porous dark mass.

772. Thrice roasted ore.

Soft dirty brown material, in small fragments (mixed with charcoal).

Materials obtained in the second operation.

773. Ore-furnace regulus, "Rohstein."

A thin regulus like a metal regulus, with transverse tubes lined with moss copper.

774. Ore-furnace slag, "Schlacke."

Of very metallic appearance: thin and heavy, more like a metal slag.

775. Copper regulus, called "Königs-Kupfer," belonging to the second operation.

A mass of dark porous copper.

776. Stoking rabble, or "Schurkrätz."

Bye product containing metal, and afterwards used. It is like a fine powdered regulus, or metal-furnace slag.

Materials obtained in the third operation.

777. Copper regulus, "Stein."

Very thin, sub-metallic, and with large holes below.

778. Slag from this fusion, "Schlacke."

A one-inch irregular slab, somewhat metallic and full of large flat holes parallel to the surface.

779. Raw roasted black copper, "Rohrost-Schwarzkupfer."

A porous mass of impure copper.

Materials obtained in the fourth operation.

780. Copper regulus, "Stein."

A very thin cake of black regulus with innumerable parallel tubes across it, often containing moss copper.

781. Slag from this fusion, "Schlacke."

A very metallic slag with large cavities.

782. Rich roasted black copper, "Kupferrost-Schwarzkupfer."

A kind of pimple metal with a black crust.

Materials obtained in the fifth operation.

783. Slag from this fusion, "Schlacke."

A very dense and heavy slag with blebs of copper on its surface.

784. Granulated copper, "Granalien."

The final result of the process.

785. Luting material, "Schmier."

A cindery kind of slag of considerable weight, containing various materials, including bits of copper.

THE LEADING AND LIQUATION PROCESS, "KUPFERFRISCH UND SAIGERARBEIT."

Products of the first operation.

786. Poor leaded slag, "Arm-frisch-Schlacke."

Glassy with large cavities, black with tinges of red. *See* Percy's Metallurgy, Silver and Gold, p. 311.

787. Poor liquation cake, "Arm-frisch-Stücke."

Consisting of copper mixed with lead in certain proportion. This specimen is merely a sample on a small scale; the actual cakes being two feet in diameter. *See* Percy's Metallurgy, Silver and Gold, p. 308.

Products of the second operation.

788. Part of the cake after liquation, or residual copper, "Kiehnstöcke."

A very irregular mass, full of openings. *See* Percy's Metallurgy, Silver and Gold, pp. 313, 323, where it is described.

789. Liquation waste, "Saigerkrätz."

Heavy rubbishy-looking fragments in a white cement, produced as a slag in the liquation process. *See* Percy's Metallurgy, Silver and Gold, p. 324, where it is described.

Products of the third operation.

790. Rich leaded slag, "Reich-frisch-Schlacke."

Glassy, black, and full of holes, said to contain 40–60 per cent. of lead. *See* Percy's Metallurgy, Silver and Gold, p. 311.

791. Rich liquation cake, "Reich-frisch-Stücke."

This also is a sample cake specially made. It has been treated with potash by R. Smith, and the copper left ascertained.

Products of the fourth operation.

792. Rich lead-cake, "Reichwerke."

A small convex mass of lead, the product of the liquation. It is rich in silver.

793. Part of the cake after liquation, or residual copper, "Kiehnstöcke."

Similar to that noticed before. *See* Percy's Metallurgy, Silver and Gold, p. 323, where it is described.

794. Liquation-waste, "Saigerkrätz."

A mass of irregular copper, mixed with slag. *See* Percy's Metallurgy, Silver and Gold, p. 324, where it is described.

RESULTS OF OPERATING ON THE LEAD-CAKE BY CUPELLATION.

795. Scum, "Abzug."

The irregular, earthy, fragmental mass which forms on the surface of the cupellation furnace, consisting of oxides of lead and of the other metals that are in the cake. *See* Percy's Metallurgy, Lead, pp. 193 and 198, where analyses are given.

796. Litharge, "Glätte."

The main product of cupellation; white and micaceous on the surface, golden yellow within.

797. Cupellation-furnace bottom, "Heerd."

A heavy, brown, earthy mass, which often contains 58–60 per cent. of metallic lead, being impregnated by the litharge that is driven off by cupellation.

Note.—The "Blicksilber" or bright silver button which is obtained by this process will be found under Silver (described in Percy's Metallurgy, Lead, p. 196).

THE PROCESS OF "DRYING" THE RESIDUAL COPPER, "DARRARBEIT."

Products of the first operation.

798. Dried residual copper, "Darrlinge."

A mass of granular copper, with cavities, and a black glaze on the surface; said to contain about 85 per cent. of copper and 15 per cent. of lead. It is obtained from this drying process performed on the liquation copper or Kiehnstock. *See* Percy's Metallurgy, Silver and Gold, p. 332, where it is described.

799. Drying-slag, "Darrschlacke."

The slag produced, which is very rich in oxide of lead. *See* Percy's Metallurgy, Silver and Gold, p. 335, where analyses are given. It contains a quantity of metallic copper in grains, and also fragments of charcoal.

800. Drying-furnace accretion, "Ofenbruch."

The marl, used as a basis, impregnated by oxide of lead driven off in the process, forming a dark, scoriaceous, heavy mass.

Products of the second operation.

The main product, "selected residual copper," "Abgepickte Darrlinge," is not present in the collection.

801. Lead and copper scale, "Pickschiefer."

Small black fragments of impure cupric oxide, which is red when powdered (sample shown), which is found on the surface of the "dried" metal. *See* Percy's Metallurgy, Silver and Gold, p. 334, where it is described.

PRODUCTS OF THE REFINING PROCESS "GAARARBEIT."

802. Refined copper, "Gaarkupfer."

In form like the hollow finger of a glove; apparently some that has run down.

803. Refinery-slag, "Gaarschlacke."

Dull red and compact. About ¾ inch thick, with large cavities and blebs of copper.

804. Refinery-waste, "Gaarkrätz."

The scum, impregnated with copper and copper salts, and of green and black tints.

PRODUCTS OF TREATING THE REFINERY-SLAG, "GAARSCHLACKENARBEIT."

Results of the first operation.

805. Regulus from refinery-slag, "Gaarschlackenkönige."

Grey granular metal, pimply on the surface.

806. Matt from refinery-slag, "Stein."

A thin cake with vertical pores, blistered on the surface.

807. Slag from refinery-slag, "Gaarschlackenschlacke."

Compact and glassy in parts. About ⅜ inch thick and very regular.

Results of the second operation or liquation.

808. Residual copper after liquating the refinery-slag regulus, "Gaarschlacken-Kiehnstöcke."

A dark grey pulverulent mass, being grains of copper coated with oxide.

809. The lead-cake obtained by the liquation, "Saigerblei."

810. Liquation-waste, "Saigerkrätz."

A loosely aggregated mass composed of the charcoal and clay, &c., impregnated with the liquated lead.

According to the scheme accompanying this collection of specimens there should be the following, which are not present.

Products of the third operation on the Residual Copper.

α. Oxidizing blast-furnace slag, "Verblasenschlacken."

See Percy's Metallurgy, Silver and Gold, p. 334.

β. Refined copper, "Gaarkupfer."

Products of treating the Oxidizing Blast-furnace Slag, "Verblasenschlackenarbeit."

First operation of fusion.

γ. Slag, "Schlacke."

δ. Regulus from blast-furnace slag, "Verblasenschlackenönige."

ε. Matt from blast-furnace slag, "Verblasenschlackenstein."

Second operation of refining.

ζ. Refinery-slag, "Gaarschlacken."

η. Refined copper, "Gaarkupfer."

It is stated that some pieces are wanting because the process is so seldom executed. This may be one such process.

TREATMENT OF THE WASTE PRODUCTS BY LEADING, "KRÄTZFRISCHARBEIT."

First operation of leading.

811. Waste-leading liquation-cake, "Krätzfrischstücke."

Small sample, earthy and showing some copper.

812. Waste-leading slag, "Krätzfrischschlacken."

A very vitreous black slag with large cavities.

Second operation of liquation.

813. Liquation-lead from waste, "Krätzblei."

814. Residual copper from the liquation, "Kiehnstöcke."

A very porous black metallic mass, of high specific gravity.

815. Liquation-waste, "Saigerkrätz."

Loose bits of impure copper, fragments of charcoal, slag, and dust.

Third operation of drying the Residual Copper.

The first product, dried residual copper or "Darrlinge," is not present.

816. Drying slag, "Darrschlacke."

A black semi-vitreous very porous slag, in small fragments.

817. Furnace accretion, "Ofenbruch."

A grey slaggy mass of loosely aggregated fragments.

Fourth operation.

818. Selected residual copper, "Abgepickte Darrlinge."

A porous mass of copper, discoloured black on the surface.

There is another product, lead and copper scale, "Pickschiefer," not present in the collection.

Fifth operation—refining the selected Residual Copper.

819. Refined copper, "Gaarkupfer."

A long hollow finger-like form, with rough exterior surface and smooth within.

820. Refinery-slag, "Gaarschlacke."

Rather red; very compact on one side, porous on the other.

TREATMENT OF THE FURNACE ACCRETIONS.

First operation.

821. Broken material from the stamping mills, "Pochwerkskratzschlieg."

Mixed waste in small pieces of various kinds.

Second operation.

822. Black copper, "Schwarz-Kupfer."

Porous, dark, and impure.

823. Slag, "Schlacke."

A ½-inch slab of compact and metalliferous sub-crystalline slag, like that from a metal furnace.

824. Matt, "Stein."

A thin, flat cake, with vertical pores, and impregnated with moss copper.

The "SAIGER" or LIQUATION PROCESS of EXTRACTING SILVER from COPPER by means of lead, as practised at the Saigerhütte, Hettstedt, Mansfeld.

LEADING PROCESS.

825. Black copper, containing silver.

This is the original material obtained by former processes, on which the Saiger operations are performed. It is a darkish copper, containing 46·67 per cent. of silver, or 152 ozs. to the ton. *See* Percy's Metallurgy, Silver and Gold, p. 307.

826. Liquating lead, "Frischblei."

(From the mines of Longbau in the county of Wirmland.) Used for adding to the copper.

827. Rich liquation cake, "Reich Frisch Stücke."

A grey, earthy-looking crumbling mass, produced by the mixture of the two metals; it contains about 11 parts of lead to three of copper, and ·164 per cent. of silver.

828. Poor liquation cake, "Arm Frisch Stücke."

Partly earthy, partly lead-like, and containing 10 parts of lead to three of copper, and ·12 per cent. of silver.

829. Slag or lead scum, "Frisch Abstrich."

Produced in the process of melting the lead and copper together. It contains a certain amount of lead, copper, iron, &c., and is a reddish-black glass, very like refinery slag.

LIQUATION PROCESS.

830. Refinery lead, "Treibblei."

Liquation cake of lead separated by the process from the black copper; it contains ·24 per cent. of silver.

831. Poor liquation lead, "Armfrischblei."

Separated from the original lead; contains ·16 per cent. of silver, and is somewhat crumbling on one side.

832. Rich residual copper from the liquation, "Reichfrisch-Kienstöcke."

It is left after the liquation, and contains about ·1 per cent. of silver; it is used for the drying process. *See* Percy's Metallurgy, Silver and Gold, p. 323. A vacuous mass coated with a pink efflorescence.

833. Poor residual copper from the liquation, "Armfrisch-Kienstöcke."

The same as the last, but contains only about ·07 per cent. of silver. *See* Percy's Metallurgy, Silver and Gold, p. 323.

834. Liquation waste or liquation thorns, "Saigerkrätz" or "Saigerdorner."

The material that boils over and trickles down the side of the liquation furnace, and thus forms a kind of stalactite, compared to thorns. These contain a mixture of lead and copper, without any separation having taken place; they are worked up again by a separate process. *See* Percy's Metallurgy, Silver and Gold, p. 320.

Cupelling Process.

835. Litharge, "Glätte."

The result of cupelling the refinery lead. This contains a little copper, and also about ·015 per cent. of silver. A loose crumbling flat mass, red in the inner layer, greenish-grey on the outside.

836. Cupellation furnace bottom, "Heerd."

A heavy brick-like mass with crystalline fracture. Produced by the lead and copper sinking into the sandy base of the furnace; the metals are recovered by a subsequent process.

837. "Blicksilber" or bright silver button.

Obtained by cupellation of the refinery lead. It contains 14½ parts of silver to 1½ parts of lead, copper and nickel.

838. Refined silver, "Brandsilber."

Obtained by refining the "Blicksilber" by remelting it.

Drying Process.

839. Dried residual copper, "Darrlinge."

Obtained when the residual copper has been cleared of its associated lead, silver, &c. A more or less porous mass.

840. Drying slag, "Darrost."

A heavy, red, compact slag, derived from the residual copper, "Kienstock," when the Darrlinge is separated. This is an oxidized product, and contains some silver and lead. This is used up later in the "Dorner" smelting. *See* Percy's Metallurgy, Silver and Gold, p. 329.

841. Drying furnace bottom or passage product, "Darrsohle."

A heavy, dark, stony substance formed by the action of the slag on the loam of the furnace walls which is attacked by it, and itself is rendered more infusible. *See* Percy's Metallurgy, Silver and Gold, p. 330.

842. Drying furnace regulus, "Darrofenzeug."

A mixture of copper, lead, and nickel obtained by smelting the drying slag, "Darrost." It contains about ·24 per cent. silver, and is used in working up refinery lead, "Treibblei." It is a loose, earthy, grey mass, with patches of visible copper.

843. Refinery slag, "Schlacke."

An opaque, brilliant, red glass, obtained in smelting the Darrsohle. It contains lead and copper, and is used for smelting again.

REFINING PROCESS.

844. Refinery slag, "Gaarschlacke."

A light, scoriaceous, dark red glass, obtained by smelting the Darrlinge in the blast of the refinery furnace. It is a red scoriaceous slag of not a great specific gravity, but still containing some lead and copper.

845. Refined copper, "Gaarkupfer."

Obtained as the main product of drying the Darrlinge. This is the final product in the way of copper; it is in a thin red sheet with local pimples.

TREATMENT OF THE REFINERY SLAG.

846. Regulus.

From smelting the refinery slag; a mixture of copper, lead, &c.; a decayed metallic mass.

847. Refinery waste slag, "Gaarkratzschlacke."

The remaining product, still containing some copper and lead, but very black, massive, and glassy.

"KRATZ" SMELTING.

848. Kratz smelting regulus, "Schmelzstück."

A decayed mixture of copper, lead, and silver, obtained by melting up the waste products and slag, including the Saigerkratz, the Litharge or Glatte, the poor residual copper, and the drying slag, "Darrost." These are mixed in definite proportion to produce the best result. *See* Percy's Metallurgy, Silver and Gold, p. 336, where a similar mixture is recorded.

849. Residual copper from Kratz smelting, "Schmelz-Kiehnstock."

This is liquated in the usual way, and the present sample is the residual impure copper left after the lead, &c. is extracted. It is decayed on the surface.

850. The lead cake from liquating the "Schmelzstück," "Schmelzblei."

This is used again for the leading process.

851. Rich slag, from *some* previous process.

Contains about 42 per cent. of lead and copper, and is used to mix with the refinery slag and the regulus obtained from it. A solid semi-glassy mass with a somewhat porous surface.

852. Once melted slag obtained in melting the last in the concentration process.

It still contains 20 per cent. of metals, the richer parts being separated as regulus; a black slightly porous glass.

853. Twice melted slag from melting the last in the concentration process.

It contains about 13–15 per cent. of metals. For the concentration process, *see* Karsten's Archiv, 1st Ser. 9. It is a black glass.

854. Thrice melted slag from the last.

Still contains metal, but in too small a proportion to be worth smelting again, and this is therefore the final waste product of all the processes. No more can be extracted by them. It is a black glass.

855. Kratz smelting liquation cake, "Schlackenstücke"?

The mixture of lead and copper obtained by smelting the material of which the last three are the slags, and is the combined product of the concentration process. It is lead-like, with a grey decayed surface.

856. The liquated lead from the liquation cake, "Schlackenblei."

857. Iron ore added to the slags for the separation of the lead.

A gravelly oxide of iron, apparently glazed by partial fusion.

The last specimen of the series which should be the residual copper from which the lead has been liquated is not present.

MISCELLANEOUS FOREIGN OPERATIONS.

858. Regulus of copper sulphides containing "Nickel" from Ekinau, Sweden.

A dark compact mass with hollow gas cavities and gravelly surface.

859. Lead ore accompanying copper pyrites used in the copper works of Finland.

It is a combination of galena and zinc blende. Communicated by E. L. Julin, 1872.

860. Furnace accretion "Ofenbruch," Finland Copper Works.

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An earthy brown porous slag. Communicated by E. L. Julin, 1872.

861. Furnace accretion "Ofenbruch" after roasting.

A compact reddish mass with large cavities. Communicated by E. L. Julin, 1872.

862. Furnace accretion "Ofenbruch," Finland Copper Works.

A black heavy glittering slag with small pores. Communicated by E. L. Julin, 1872.

863. "Skumnas" from the Åtvitaberg Copper Works, Sweden.

A light grey compact opaque iridescent glass mixed with crystalline matter. A product of the imperfect roasting formerly effected. It formed a covering on the surface of the melted regulus, and contains a large amount of sulphide of zinc as well as copper. It is now no longer formed, owing to improved methods, and the old skumnas has been worked up again for copper. *See* Percy's Metallurgy, 1861, p. 402.

864. Slag from Cyprus.

Contains copper 0·59 per cent., iron 6·5 per cent. Another piece, contains 8 per cent. of silica and a quantity of manganese, lime, &c. A good clean compact earthy slag, as clean as is now made.

865. Copper slag said to come from Arabia Petræa.

Dark, massive, and crystalline, weathering to green. Communicated by Trenham Reeks.

Specimens illustrating the extraction of silver from copper by liquation in Japan. Supplied by C. Tookey, late assayer to the Japanese Mint.

866. Coarse copper from which the silver is to be extracted, "Arado."

A thin blistered cake.

867. Copper mixed with lead for liquation, "Awasido."
Grey and porous.

868. Copper after the lead has been liquated from it, "Siborido."

Irregular and vacuous.

869. Liquation cake of lead containing the silver, "Denamari."

870. The litharge remaining in the cupels, "Rukasu."
Stony and transversely crystalline.

871. Coarse lead, "Aranamari."

872. The silver extracted by cupellation from the lead "Dehaifukigin."
A thin slab.

873. The liquated copper not containing silver, "Mafukido."

Melted and cast under water in the usual way, making it red and vacuous.

VARIOUS FORMS OF COPPER.

874. Overpoled copper from the Spitty Copper Works, Swansea, 1848.

This shows the development of the longitudinal ridge to an extraordinary degree. Communicated by Jas. Napier.

875. " Best selected " copper.

Found, nevertheless, to be inferior. Communicated by T. Moor.

876. "Bean-shot" copper. From the Hafod Works, 1848.

A form of commercial copper produced by lading the copper into hot water, so that it does not cool so very rapidly, by which means it takes on the form and size of flat haricot beans. *See* Percy's Metallurgy, 1861, p. 326.

877. "Feathered shot" copper, from the Hafod Works, 1848.

Produced by lading overpoled copper into cold water, thus cooling it as rapidly as possible, producing the shape of ordinary granulated zinc. *See* Percy's Metallurgy, 1861, p. 326.

878. Triturated copper, produced by shaking the copper in water when heated.

In small irregular granules.

879. Copper broken when red hot.

Showing an imperfect arborescent crystallisation in the centre, and in the border round the surface a coarse fibrous or pseudo-columnar structure.

880. Copper accidentally crystallised. From the Mines Royal Copper Works, Neath, 1869.

Crystallised in rectangular arborescent forms, similar to those of the regulus, but built up into large skeleton pyramids, black on the surface. Communicated by W. Edmonds.

881. Copper from under the pigs of metal from the second running down in making "best selected" copper. Mines Royal, Neath.

Communicated by W. Edmonds.

882. Crystallised copper from a pig of dry copper.

From Newcastle-on-Tyne, where pyritic copper residues are treated by a "wet" process. It shows pointed arborescent copper-coloured outgrowths.

883. Cake copper, the result of the "best selected" process.

Made when inferior ore was being used.

884. Cake copper which has been "broken down" hot, but which crumbles before the cut of the shears when cold.

From Cwn Avon Copper Works. It has been analysed by C. Tookey, and in 100 parts of copper is found to contain lead ·43, antimony ·09, iron ·02, sulphur ·17, and traces of arsenic; total impurities ·557 per cent. Communicated by C. Clifford.

885. Sheet of the same copper rolled cold.

It has a rich red fracture, but is very rotten. Communicated by C. Clifford.

886. Best selected copper which has been re-melted and poured into an iron ingot mold.

Made in 1848 in illustration of a lecture on copper smelting to the British Association. This has been broken across and shows coarse crystalline fibres radiating from the angles to the centre, and the edges are much cracked.

887. Samples illustrating the process of refining by means of phosphide of copper.

They include the dry copper without the phosphide, the same when the phosphide has been added, and the final result when the copper has been brought to tough pitch. Chatham, 1875. They are seen to differ in the lustre and colour of the fracture.

888. Two specimens of copper cast under water on the Japanese plan.

See Percy's Metallurgy, 1861, p. 394. These ingots were cast by Dr. Percy without difficulty and the metal was poured at a high temperature. The difference of colour of these two specimens is remarkable; it is probably due to a difference of temperature in the water or in the molten copper, or in both. They were made from the same "best selected" copper.

889. Copper from the bed of a copper furnace at Hafod Works, Swansea, 1848.

Of a beautiful yellow colour. The formation in this case was quite accidental, but it closely resembles the tint produced by casting under water. It is entirely superficial, as is seen by a cut on the side, and is probably due to a film of cuprous oxide of a certain thickness coating the metallic copper.

890. Turning off copper roll for calico printing works. From Newton, Keats, and Co., St. Helen's, Lancashire, 1881.

891. Copper for vents of guns, &c. used in the Royal Gun Factory, Woolwich.

Procured from Pontifix, supposed to be entirely free from impurities.

892. Ingot of copper melted from the borings of "Bearing metal."

Communicated by Mr. May, 1871.

893. Specimens illustrating the casting of copper.

Two porous ingots and two dense ingots. The porous ones have deep holes in the bottom, making it honeycombed. *See* A. Dick, Phil. Mag., vol. XI., 1856.

894. Samples of copper which by themselves have shown a want of malleability, but which, notwithstanding, made very good brass.

Communicated by Mr. Keats in 1849.

895. Series of bars of copper produced by Parkes' process.

No. 1. Copper from sulphide ores after six hours' calcining and four hours' smelting. No. 2. Copper as No. 1, but fused a second time with chloride of calcium for $1\frac{1}{2}$ hours, and not poled. No. 3. Copper from carbonate ores produced by Parkes' process in 2 hours. No. 4. Deposited copper fused with charcoal. No. 5. Deposited copper fused with chloride of calcium.

896. Copper produced by Bankart's process.

See Percy's Metallurgy, 1861, p. 447. A solid square ingot.

897. Metallic copper reduced by coal from impure oxide.

A dark brown earthy-looking powder.

898. Electro-deposited copper on iron rollers for calico printing.

Broughton Copper Works, Manchester. The deposit is remarkably hard and tough, nothing having been done to it beyond etching the pattern. The rusty appearance at the back shows the intimate connexion between the copper and iron at the surface of junction.

899. Electrotype copper deposited in a stalactitic form.

Caused by very rapid action (?). These are a pair of long bars on which the copper has grown out in mammillated forms at right angles to the surface.

900. Electrotype copper in a thin dense sheet.

901. Electro-deposited copper from the Pembrey Copper Works, Birmingham.

Showing the double layer round the original sheet and the transversely fibrous structure. *See* Percy's Metallurgy, Silver and Gold, p. 499. Communicated by Mr. Elkington, 1880.

902. Electrotype copper in ingot.

Cast by Messrs. Elkington and Co., Birmingham; the same as used by Captain James in his experiments on the corrosive action of sea water.

903. Electrotype copper, hard and not good for German silver.

904. Electrotype foil.

Made from copper not annealed before rolling by Elkington and Co.

905. Electrotype foil.

Made from copper annealed before rolling by Elkington and Co.

906. Wire from electro-deposited copper.

From Morfa Copper Works, Swansea, 1883. Communicated by Mr. Cady.

907. Residue obtained in copper electrotyping.

Communicated by Messrs. Elkington. A green earthy powder.

908. Copper with 1·3 per cent. of arsenic.

The electric conductivity of the wire drawn from this is only 20 per cent. of that of pure copper. This was refined in the usual way at Broughton Copper Works, Manchester, and was very red-short, 1882.

909. Copper wire, containing 0·17 per cent. of lead.

Analysed by A. Dick.

910. Beechwood impregnated with native copper.

Part of a beam in a smelting house in Sweden.

911. Atten copper, Norway.

Showing a very flat ingot. Imported by Evans and Askin, Birmingham, 1848.

912. Peculiar coloured copper from a mass of Russian metal.

The slabs of metal had some very large holes in the centre, and this specimen shows the colour next the holes. Imported to Birmingham, 1849. Communicated by P. Moore.

913. Slab of copper from Lake Superior.

Of a very yellow tint on the surface. *See* Experiment by Dr. Percy, whose results are shown in No. **888**. Communicated by J. L. Cooker.

914. Part of an ingot of copper from Lake Superior.

Said to be entirely free from arsenic. Communicated by Dr. Matthiesen, 1881.

915. Copper obtained from stamping native copper ore at Lake Superior.

The original rock yields only 1·2 per cent. of copper, or 400 lbs. per cubic fathom; but the native copper is disseminated through it in various sized pieces. These are the largest pieces which are obtained when the rock is crushed and the powder separated. These become attached to the stamp heads, and will not go through the gratings, but are all small, less than a farthing in size, except a large stamped out-piece. They yield 99 per cent. of metallic copper. Communicated by Mr. Petherwick.

916. Copper obtained from stamping native copper ore at Lake Superior.

This is from the same rock, and consists of the minute fragments which go through the first and second gratings. It yields 90 per cent. of copper besides some silver. Communicated by Mr. Petherwick.

917. Copper obtained from stamping native copper ore, Lake Superior.

This is from the same rock, and is the finest copper dust obtained; it contains 60 per cent. of copper. Communicated by Mr. Petherwick.

918. Laminated copper from Lake Superior.

This has been purified and treated to obtain the per-centage of copper in the stamp material. In flat scales. Communicated by Mr. Petherwick.

919. Copper from Burra Burra, Australia, 1848.

This contains antimony, and makes bad brass. Smelted at Moore's Works. *See* Percy's Metallurgy, 1861, p. 504.

920. Copper produced by Rodda's patent.

Reduced by cementation, stamping and washing. From the Australian Exhibits at the Exhibition of 1862. It is a fine-grained, cracked, porous, copper-coloured mass of very small specific gravity *as a whole.*

921. Slab of Japan copper called tile copper.

Showing the peculiar red surface colour characteristic of their method of casting, which is by pouring the molten liquid into water. Much of this is imported into Liverpool. *See* Percy's Metallurgy, 1861, p. 192.

922. Triangular ingot of Japan copper.

These are of small size and triangular section, as usually made. The colour is said to be produced by throwing the ingots, as soon as solid, into cold water. This sample has been analysed by A. Dick, and found to contain 0·13 per cent. of nickel, 0·03 per cent. of iron, and extremely minute traces of tin and gold, but there is no appreciable quantity of cobalt, or of the metals of the alkalies or alkaline earths. *See* Percy's Metallurgy, 1861, p. 394.

923. "White copper" from the Province of Yun-nan, China.

Melted from the ore, not an artificial compound. It is a black, very porous mass, apparently of metal.

924. A piece of "white copper," or Pĭh-tung, from the Province of Yun-nan, China.

This is cast into a small ingot of rectangular shape, and has a very fine fracture, but from its very light yellow colour it is obviously an alloy, probably a native one. Communicated by Dr. Lockhart, 1858.

925. Copper containing silicon cast into a medallion.

Prepared by heating copper to whiteness in contact with silica and carbon. The medallion was cast by Messrs. Robinson and Cotton. The metal requires a higher temperature for fusion than bronze. The metal was prepared by A. Dick, and found to contain 1·82 per cent. of silicon. *See* Percy's Metallurgy, 1861, p. 282.

926. Two bars of Japanese copper.

Broader than the usual kind. A large quantity of this copper has been imported into Liverpool. Communicated by D. Watson, 1872.

927. Two discs of Japanese copper.

These are comparatively seldom imported into this country. They are slightly convex, about 5 inches in diameter, of a brilliant red colour, and not completely refined. Communicated by D. Watson, 1872.

928. A series of copper "proofs," taken out for testing the copper in the process of poling. Morfa Copper Works.

See Percy's Metallurgy, 1861, p. 325. (*a*) has been poled for 15 minutes, and is rough and granular; (*b*) for 20 minutes, and is slightly fibrous or platy; (*c*) for 25 minutes, and is granular; (*d*) for 30 minutes, and is highly fibrous; (*e*) for 35 minutes, and is coarsely fibrous; (*f*) for 40 minutes, and is finely fibrous and platy; (*g*) for 45 minutes, and is granular and finely fibrous; (*h*) for 50 minutes, and is very finely fibrous, scarcely brittle, but bends, when it is considered to be good; (*i*) for 55 minutes, when the poling is perfect, it can be torn, but not broken; (*k*) for 60 minutes, and is coarsely fibrous, when it is overpoled; (*l*) for 65 minutes, and is slightly fibrous; (*m*) has been poled for 20 minutes and then allowed to cool in the air instead of in water, and is crystalline and platy.

929. Sample of copper sheeting from Cwm Avon Copper Works.

Exhibited at the International Exhibition, 1862.

930. Russian sheet copper.

From the International Exhibition, 1862.

931. Swedish sheet copper.

From the International Exhibition, 1862.

932. Large "rosette" of Swedish (?) copper.

About 2 feet in diameter, smooth on one side, and rough on the other.

933. Smaller "rosette" of copper, from blast furnaces.

About 18 inches in diameter.

RESULTS OF TREATING COPPER IN VARIOUS WAYS.

934. Electrotype copper, melted under charcoal and left to cool in the crucible.

Experiment by A. Dick, showing that under these circumstances the copper contracts and crystallises in fern-like branches, leaving a cavity in the centre. *See* Percy's Metallurgy, 1861, p. 275.

935. Electrotype copper, melted under charcoal and poured out into a mould.

Experiment by A. Dick, to show the porous structure and the raised band along the centre of the ingot produced by the ordinary process. *See* Percy's Metallurgy, 1861, p. 276.

936. Best selected copper, melted under charcoal and cast into an ingot mould.

Showing the vesicular structure produced by the ordinary method.

937. Wire and foil from copper which had been melted in charcoal and allowed to cool in the crucible.

Experiment by A. Dick. *See* Phil. Mag., vol. XI., 1856.

938. Russian copper, melted under charcoal and cast in the usual way.

Experiment by A. Dick, showing a raised surface to the ingot and a porous fracture. *See* Percy's Metallurgy, 1861, p. 276.

939. Best selected copper from Messrs. Newton and Co., Greenfield, Holywell.

This has been reduced to powder by trituration when hot, mixed with black oxide of copper and melted. Cast in an iron ingot mould. Annealed and rolled afterwards. Rolled at Clifford's Mills, Birmingham, 1848.

940. Best selected copper from Messrs. Newton and Co.

This has been melted alone and cast in an iron ingot mould. Annealed and rolled afterwards. The edges are cracked as usual when copper is cast alone in small quantity and rolled. Rolled at Clifford's Mills, Birmingham, 1848.

941. Best selected copper from Messrs. Newton and Co.

This has been melted, and metallic arsenic dropped into the melted metal and stirred well. Cast in an iron ingot mould, annealed and rolled. Annealed twice after the first rolling. Here the edges are clean. Analysed by A. Dick, it contains silicon and phosphorus derived from the ash of the charcoal. Rolled at Clifford's Mills, Birmingham, 1848.

942. Best selected copper from Messrs. Newton and Co.

Artificial sulphide of copper was added to the melted metal, which was then cast in an iron ingot mould, annealed and rolled. It has broken down altogether. Rolled at Clifford's Mills, Birmingham, 1848.

943. Best selected copper from Newton, Keats, and Co.

This was reduced to powder by triturating it in a mortar when hot, the finest particles were sifted out, and cemented with carbon for seven or eight hours at or near the melting-point; at the end of this time, the copper was found in round globules imbedded in the charcoal; the latter was blown away, the metal remelted with carbon, and cast and rolled, which it submits to very well. Another portion of the same was drawn out into wire, 1848. *See* Percy's Metallurgy, 1861, p. 270. Illustration of Lecture to British Association at Swansea.

944. Copper cemented in charcoal powder.

This is another portion of the same copper as No. **943**; an attempt has been made to forge it at a red heat without success on account of its brittleness. *See* Percy's Metallurgy, 1861, p. 270.

945. Best selected copper from Newton, Keats, and Co.

In this, phosphorus has been dropped into the melted metal and stirred. It rolls well, but is harder than that simply cemented or heated with carbon, 1848.

946. Copper sheet, tested by hammering.

Phosphorus was used in refining as suggested by W. Weston, of Chatham Dockyard, 1878. It is folded twice flat without the slightest sign of breakage.

947. Copper wire become dry under special circumstances.

It was drawn hard in the usual manner, put into a cast-iron annealing pot with lid, and luted with clay to make it air-tight. It was then put into an ordinary "muffle" furnace, and left for an hour, and afterwards cooled in the air. The inside of the pot which had been used for brass annealing was slightly coated with zinc oxide, possibly mixed with carbon from the suds used in the wire drawing. Communicated by J. Hughes, of Newton, Keats, and Co., 1881.

948. Copper wire which has been tough, but has become brittle.

It lay about for five years in a laboratory, and was then found to have changed its character. Communicated by J. F. Ansill.

949. Two samples of brass wire, one "short," the other sound.

They are from the same coil, but the "short" one has been exposed to the air of a laboratory for two years and has become tarnished, the other which is sound has been kept in a drawer. Communicated by Major Peile.

950. Copper containing 0·31 per cent. of antimony and 0·29 per cent. of lead.

The electric conductivity of the wire at 12° as tested by Dr. Matthiesen is 64·5, the standard of pure copper at 15½° being 100. With these are two pieces of the same wire melted under carbon and hammered out hot and cold. The piece hammered out has cracked. *See* Percy's Metallurgy, 1861, p. 288.

951. Wire made from the sheathing of H.M.S. "Fantome," 1867.

The electric conductivity of pure copper at 11° C. being 95·3, that of this wire as determined by Dr. Matthiesen is 59·4.

952. Wire made from the sheathing of H.M.S. "Argonaut."

The electric conductivity as determined by Dr. Matthiesen is 64·5.

953. Electrotype and common copper heated in hydrogen.

The former is unaltered, the latter is rendered brittle.

954. Electrotype and common copper heated in coal gas.

The former is unaltered, the latter is rendered brittle.

955. Electrotype and common copper heated in carbonic oxide.

The former is unaltered, the latter is rendered brittle.

956. Electrotype wire and foil heated in ammonia.

It is unaffected.

957. Ordinary copper wire heated in ammonia.

It is rendered brittle, and though heated in steam to try to anneal it, no annealing took place under this treatment.

958. Copper wire and foil from a porous ingot of electrotype copper.

Cast under ordinary circumstances. Experiment by A. Dick. The relative conductivity of this wire at 13° to that of pure unmelted electrotype copper at 15°·5 is 98·8 per cent. *See* Percy's Metallurgy, 1861, p. 286. *See also* A. Dick, Phil. Mag., vol. XI., 1856.

959. Copper wire and foil from a dense ingot of electrotype copper.

It had been melted under charcoal which had been digested in hydrochloric acid. Experiment by A. Dick. The relative conductivity in this case is 93·2. *See* Percy's Metallurgy, 1861, p. 288 ; and also Phil. Mag., vol. XI., 1856.

960. Electrotype copper, melted under charcoal and poured into the mould under burning coal gas.

Experiment by A. Dick. The surface is depressed, and there is no porosity in the fibre of the fracture ; it is pale salmon in colour. *See* Percy's Metallurgy, 1861, p. 276.

DEFECTS IN COPPER.

961. Defective copper from the Governor and Company of Copper Smelters.

Obtained during the working up of furnace bottoms, 1848. It exfoliates in rolling. From Clifford's Mills, Birmingham.

962. "Spilly" copper from smelting furnace bottoms.

At Newton, Keats, and Co., Holywell. Communicated by W. Keats, 1871.

963. Defective sheet copper too hard to spin into shape.

It has torn away from the side. Intended for a carriage lamp. Communicated by Randolph Clay, 1878.

964. Copper wire, cemented by heating in an annealing pot containing brass wire.

The copper wire has been left in the luted annealing pot for 12 hours, and has become brassy on the outside by imbibing the fumes of zinc given off by the heated brass wire, but it is copper-red within, it has also become more brittle, and its diameter has slightly increased. The brass wire at the same time became softer. Three samples of copper were thus treated, and they severally increased in diameter from 0·341 in. to 0·344 in., from 0·121 in. to 0·125 in., and from 0·039 in. to 0·043 in. Similar pieces of copper wire when heated in exactly the same way, except in the absence of the brass wire, decreased from 0·0256 in. to 0·0255 in., from 0·137 in. to 0·135 in., and from 0·040 in. to 0·038 in. This was due partly to scaling, which does not occur when the brass wire is present. Experiment by Thomas Hughes, Greenfield Copper Works, Holywell, 1871.

965. Corroded copper tube from steam boiler.

The corrosion has taken place at the spots where the horizontal tubes were supported by a vertical sheet of gun-metal. The corrosion occurred in about 30 days, all the tubes being corroded. Communicated by C. Wigram, 1876.

966. Defective copper, split in rolling at Clifford's Mills, Birmingham.

967. Copper cracked on cutting.

The cracked surface supposed to have been exposed to fumes of sulphur. Clifford's Mills, Birmingham, 1848.

968. Copper cracked in rolling.

From the Forrest Works (Cwm Avon) when smelting furnace bottoms. Clifford's Mills, Birmingham, 1849.

969. Piece of copper tube on the surface of which appear spiral marks caused by drawing through the die.

The question is suggested whether, on the tube cracking from any cause, the cracks would follow these lines.

WEARING OF COPPER.

SHEATHING WHICH HAS BEEN USED IN H.M. NAVY.

These specimens have been supplied by the Chemical Department of the Admiralty, and illustrate the length of time such sheathing lasts, and the method of its decay as dependent on the different circumstances indicated in each case.

The following 22 are examples of great durability:—

970. Copper sheathing from H.M.S. "Forth." Put on September 1832. Taken off November 1845.

Payed with coal tar originally, but with vegetable tar when repaired in 1839. The copper put on in 1839 was eaten into holes at the water line. Four sheets were also put on at the same time under the bottom, and when examined, in 1845, were eaten to shreds. Average loss per sheet, 1 oz. per annum.

971. Copper sheathing from "Plymouth" yacht. Put on March 1825. Taken off March 1846.

Payed with vegetable tar. The vessel lay generally near a large extent of mud, and it is probable that the slimy coating arising therefrom may have defended the face of the copper. Average loss per sheet, 0·5 oz. per annum.

972. Copper sheathing from H.M.S. "Cambrian," marked "O.M." Put on August 1846. Taken off April 1851.

973. Copper sheathing from H.M.S. "Cambrian," marked "G." Put on and taken off as above.

Payed with vegetable tar. The durability of these specimens was plainly visible, when compared with the remainder of the copper on the bottom, marked "IV." and "$\frac{1}{5}$," which lost 9 and 8 oz. per sheet per annum. Average loss per sheet of these, "O.M." 3·8 oz., and "G." 4·2 oz. per annum.

974. Copper sheathing from H.M.S. "Laimia." Put on September 1816: Taken off January 1852.

Payed with coal tar. Average loss per sheet, 0·67 oz. per annum.

975. Copper sheathing from H.M.S. "Lucifer." Put on February 1844. Taken off November 1849.

Payed with coal tar. The durability of this sheathing does not appear to be attributable to the quality of the copper, but rather to the circumstances to which it was exposed in relation to the coal tar or boiler water. Average loss per sheet, 0·7 oz. per annum.

976. Copper sheathing from H.M.S. "Saracen." Put on February 1831. Taken off December 1851.

Payed with coal tar. Average loss per sheet, 1·125 oz. per annum.

977. Copper sheathing from H.M.S. "Astrea." Put on May 1823. Taken off April 1851.

Payed with a composition of coal tar and coal pitch. Average loss per sheet, 0·475 oz. per annum.

978. Copper sheathing from H.M.S. "Chatham," marked "$\frac{1}{4}$." Put on July 1825. Taken off December 1843.

Payed with vegetable tar. Average loss per sheet, 0·58 oz. per annum.

979. Copper sheathing from H.M.S. "Chatham." Put on June 1833. Taken off December 1843.

Payed with vegetable tar. Average loss per sheet, 1·6 oz. per annum.

980. Copper sheathing from H.M.S. "Chatham," marked "V." Put on August 1817. Taken off December 1843.

Payed with vegetable tar. Average loss per sheet, 0·33 per annum. This vessel had Davy's protector applied in 1825, when she was partially stripped and re-coppered. No waste appeared to have occurred in the sheathing for a long time, the bottom being covered with weed and barnacles with a smooth brown coating of mud.

981. Vivian's bronze sheathing from H.M.S. "Express." Put on 1835. Taken off September 1843.

Payed with coal tar. This sheathing was taken off on account of the adhesion of weed and barnacle. Average loss per sheet, 3·75 oz. per annum.

982. Copper sheathing from H.M.S. "Falmouth." Put on September 1837. Taken off November 1843.

Payed with vegetable tar. From the keel upwards about 6 ft. the sheathing had acquired a smooth brown coating by coming in contact with muddy water.

983. Copper sheathing from H.M.S. "Nereus." Put on September 1821. Taken off August 1843.

Payed with a mixture of coal tar and coal pitch. This copper had Davy's protector applied in 1826, which, when taken off in 1843, had become decomposed, leaving merely spongy lumps of carbonate of iron, which for some time has reacted destructively on the sheets immediately contiguous, and eaten them into large holes, the remainder being generally very little worn. Average loss per sheet, 0·83 oz. per annum.

984. Copper sheathing from H.M.S. "Impregnable." Put on April 1826. Taken off July 1843.

Payed with a mixture of coal tar and coal pitch. Average loss per sheet, 0·6 oz. per annum.

985. Copper sheathing from H.M.S. "Medway." Put on December 1820. Taken off May 1847.

Payed with a mixture of coal tar and coal pitch. Remarkable as one of four ships which had remained at Hamoaze from the first coppering without the sheets becoming perforated at the water line. All payed in the same way; while fifteen others coppered since 1830, and payed with vegetable tar, had all had the sheathing eaten into holes, under similar circumstances. Average loss per sheet, 0·8 oz. per annum.

986. Copper sheathing from H.M.S. "Netley." Put on March 1821. Taken off February 1845.

Payed with vegetable tar. The durability of this sheathing would appear to be due to the quality of the copper alone. Average loss per sheet, 0·66 oz. per annum.

987. Copper sheathing from H.M.S. "Favorite." Put on September 1833. Taken off January 1846.

Payed with vegetable tar. Average loss per sheet, 1·66 oz. per annum.

988. Copper sheathing from H.M.S. "San Josef." Put on December 1831. Taken off April 1849.

Payed with coal tar and pitch. This copper was clean on the surface and not perceptibly worn or eaten at the water line. Average loss per sheet, 0·42 oz. per annum.

989. Copper sheathing from H.M.S. "Gosport." Put on December 1823. Taken off August 1846.

Payed with vegetable tar. The durability of this sheathing would appear to be due to the quality of the copper alone. Average loss per sheet, 0·5 oz. per annum.

990. Copper sheathing from H.M.S. "Portland." Put on January 1840. Taken off February 1846.

Payed with vegetable tar. This sheathing was slightly honeycombed, but not eaten at the water line. Average loss per sheet, 0·5 oz. per annum.

991. Copper sheathing from H.M.S. "Aurora." Put on February 1825. Taken off April 1851.

Payed with a mixture of coal tar and pitch. Average loss per sheet, 0·9 oz. per annum.

The following 12 are examples of least durability:—

992. Copper sheathing from H.M.S. "Petrel." Put on May 1838. Taken off September 1843.

Payed with coal tar. Average loss per sheet, 17·5 oz. per annum, due to the mechanical action of the sea water.

993. Copper sheathing from H.M.S. "Apollo." Put on January 1838. Taken off September 1843.

Payed with vegetable tar. Average loss per sheet, 8 oz. per annum, due to the mechanical action of the sea water.

994. Copper sheathing from H.M.S. "Indefatigable." Put on September 1849. Taken off November 1849.

995. Copper sheathing from H.M.S. "Indefatigable." Put on and taken off with the above.

Both payed with vegetable tar, partially neutralised by lime. Corroded only at the water line, where the sheets were eaten into holes all round the ship, as almost invariably occurs on newly coppered ships which remain in Hamoaze.

996. Copper sheathing from the rudder of H.M.S. "Melampus." Put on February 1835. Taken off March 1845.

Payed with vegetable tar. It remained green while in dock. Average loss per sheet, 2·15 oz. per annum.

997. Copper sheathing from H.M.S. "Melampus." Put on April 1843. Taken off March 1845.

Payed with vegetable tar. Average loss per sheet, 6 oz. per annum, which took place at the water line, where the sheets were eaten quite through in large holes.

998. Sterling's patent mixed metal sheathing from H.M.S. "Britomart." Put on February 1850. Taken off December 1850.

Payed with coal tar. Taken off the bottom within the year on account of the edges and fastenings of the sheets being eaten away round the nail heads.

999. Copper sheathing from H.M.S. "Penguin." Put on April 1838. Taken off November 1843.

Payed with coal tar. Average loss per sheet, 13·75 oz. per annum, due to the mechanical action of the sea water.

1000. Copper sheathing from H.M.S. "Petrel." Put on September 1847. Taken off April 1850.

Payed with vegetable tar. Average loss per sheet, 13·6 oz. per annum, due to the mechanical action of the sea water.

1001. Copper sheathing from H.M.S. "Crane." Put on January 1844. Taken off July 1847.

Payed with vegetable tar. Average loss per sheet, 11 oz. per annum, due to the mechanical action of the sea water.

1002. Copper sheathing from H.M.S. "Swift." Put on April 1838. Taken off November 1843.

Payed with vegetable tar. Average loss per sheet, 13·6 oz. per annum, due to the mechanical action of the sea water.

1003. Copper sheathing from H.M.S. "Calliope." Put on August 1849. Taken off November 1850.

Payed with coal tar neutralised with lime. Eaten into holes at the water line.

1004. Copper sheathing from H.M.S. "Naid." Put on June 1828. Taken off August 1846.

Average loss per sheet, 8 oz. per annum.

1005. Copper sheathing from H.M.S. "Acteon." Put on April 1845. Taken off March 1848.

Average loss per sheet, 5·3 oz. per annum.

The rate of wear of the following has not been ascertained.

1006. Copper sheathing from H.M.S. "Portland." Put on January 1840. Taken off February 1846.

1007. Copper sheathing from H.M.S. "Aurora." Put on February 1825. Taken off April 1851.

1008. Copper sheathing from H.M.S. "Leviathan." Put on 1817. Taken off 1847.

1009. Copper sheathing from H.M.S. "Eurydice." Put on May 1843. Taken off July 1846.

1010. Copper sheathing from H.M.S. "Resistance." Put on 1840. Taken off 1846.

1011. Copper sheathing from H.M.S. "Duke." Put on 1794. Taken off 1843.

1012. Copper sheathing from H.M.S. "Helena." Put on September 1847. Taken off June 1848.

1013. Copper sheathing from H.M.S. "Frolic." Put on August 1847. Taken off June 1848.

1014. Samples of old copper sheathings without special information from the Chemical Department of Admiralty.

Stamped with numbers: (3) "Eurydice." (5) "Cambrian." (10) "Duke." (11) "Thunder." (12) "Letitia." (13) "Royal George." (14) "Argonaut." (15) "Leviathan." (16) "Frolic." (17) "Resistance." (18) "Helena." (19) "Amphitrite." (26) "Acteon." (44) "Collingwood." (45) "San Josef." (48) "Success." (138) "Sprightly." (139) "Sprightly." (176) "Electra." (179) "Electra." (189) "Apollo," average loss per annum $6\frac{1}{4}$ oz. (209) "Hussey." (226) "Amphitrite." (222) "Amphitrite," W. (232) "Topaze. (242) "Letitia." (251) "Ajax." (255) "Acheron." (256) "Spiteful." (258) "Athol." (260) "Royal William," N., one of the worst sheets (261) "Royal William." (265) "Meeanee." (266) "Meeanee." (269) "Blenheim," average loss per sheet 5 oz. in 5 years. (271) "Blenheim," average loss per sheet $4\frac{5}{6}$ oz. in 5 years. (273) "Blenheim," average loss in 2 years 11 months 1 lb. $1\frac{1}{6}$ oz. (275) "Arrogant." (276) "Arrogant." (277) "Winchester," loss 14 oz. per sheet. (286) "Hecla," average loss $9\frac{1}{4}$ oz. in $3\frac{1}{2}$ years. (289) "Flying Fish," average loss 14 oz. (290) "Pantaloon," average loss per sheet 2 lbs. 6 oz. in 4 years. (291) "Pantaloon," average loss per sheet 2 lbs. $5\frac{1}{4}$ oz. in 4 years. (299) No. 1 Lighter. (296) "Meeanee." (300) "Sampson." (328) "Rapid," which lay on the bottom 12 months, average loss per sheet $7\frac{1}{2}$ oz. (329) "Rapid," which lay on the bottom 12 months, loss $1\frac{1}{2}$ oz. per sheet. (342) "Hercules," average loss 1 lb. $2\frac{1}{2}$ oz. (349) "Grampus," average loss per sheet 6 oz. in 3 years. (353) "Grampus," average loss per sheet 3 oz. in 3 years. (354) "Stirling Castle," which lay at the bottom for 33 years, average loss per sheet 1 lb. 5 oz.

1015. Copper sheathing from the ship "Frolic."

Rolled in Birmingham.

1016. Copper sheathing from the bottom of H.M.S. "Argus."

Showing an unusual method of corrosion in long parallel streaks. It has been fixed ten years. The last part of the time in the West Indies.

1017. Defective nails from H.M.S "Flying Fish," with sheathing.

The sheathing was fixed with these nails in January 1874, and had to be taken off again in June of the same year, owing to the heads of the nails coming off by the action of the sea water upon them. The original nails are here also.

1018. Copper sheathing from H.M.S. "Hound." Put on May 1846. Taken off September 1849.

1019. Copper sheathing from H.M.S. "Thunder." Put on August 1841. Taken off September 1844.

Made of new cake copper, marked N. The average loss per sheet per annum was 8 oz.

1020. Copper sheathing from H.M.S. "Fantome." Put on March 1844. Taken off December 1844.

Made of new cake copper, marked N. Loss per sheet per annum 5·62 oz. This sheathing has been analysed by C. Tookey, and found to contain: lead ·1187, bismuth ·1240, antimony ·0143, arsenic 0·1908, iron ·0042, nickel ·0287 per cent. *See* Percy's Metallurgy, 1861, p. 624.

1021. Copper sheathing from H.M.S. "Duke." Put on 1794. Taken off 1843.

Average loss per sheet per annum 0·73 oz.

1022. Copper sheathing from H.M.S. "Meeanee." Put on at Bombay, 1841. Taken off at Chatham, 1851.

New cake copper, marked N. Average loss per sheet per annum 7 oz.

1023. Copper sheathing from H.M.S. "Boadicea." Put on December 1830. Taken off April 1858.

Remanufactured sheathing. Loss per sheet per annum 0·5 oz.

1024. Copper sheathing from H.M.S. "Spy." Put on July 1848. Taken off November 1850.

New cake copper, marked N. Loss per sheet per annum 8·36 oz.

1025. Copper sheathing from H.M.S. "Argonaut." Put on December 1790. Taken off December 1830.

Loss per sheet per annum 0·17 oz.

1026. Copper sheathing from H.M.S. "Argonaut." Put on 1790. Taken off 1830.

In this specimen are seen straight broad lines drawn both ways from nail-hole to nail-hole, and there is also the arrow-mark preserved in the same way. It is suggested that before it was customary to mark the position of the nail-holes, lines were drawn with a steel tool called a scribe, to fix their position, and along these lines so marked the copper has been indurated, and thus is better preserved. In proof of this it is noted that copper cast under pressure has its strength increased 40 per cent. *See* Article by Dr. Percy, Trans. Inst. C. E., Oct. 1880. Communicated by W. Weston, 1873.

1027. Specimen showing corrosion of copper in bilge-water.

This copper strainer was placed to protect the suction pipe of auxiliary bilge-pump of s.s. "Durham," belonging to Money, Wigram, and Sons. It was fitted in Jan. 1875, and had to be taken out on account of its corrosion in July 1878. Communicated by Clifford Wigram.

1028. Copper wire rope used as lightning conductor in a chimney.

It originally consisted of seven strands, each strand of seven wires, but the whole is now almost entirely fused together, showing the effects of lightning on copper wire. Communicated by R. S. Newall.

ALLOYS OF COPPER.

The following 26 experimental alloys, all made by R. Smith, are in the form of small buttons, broken to show their fracture.

1029. Alloy of 999 copper and 1 antimony.
Copper-like, granulated.

1030. Alloy of 995 copper and 5 antimony.
Copper-like, granulated.

1031. Alloy of 90 copper and 10 antimony.
A little lighter in tint.

1032. Alloy of 80 copper and 20 antimony.
Of a reddish-grey tint, with a granular fracture.

1033. Alloy of 75 copper and 25 antimony.
Of a warm grey tint, slightly crystalline in fracture.

1034. Alloy of 70 copper and 30 antimony.
Of a grey tint tarnishing yellow, platy and crystalline in fracture.

1035. Alloy of 60 copper and 40 antimony.
Of a grey tint with a red tarnish, strongly platy in fracture.

1036. Alloy of 55 copper and 45 antimony.
Like No. **1034.**

1037. Alloy of 57 copper and 43 antimony.
Like No. **1036.**

1038. Alloy of equal parts of copper and antimony.
Of a warmish tint, in broad crystalline plates.

1039. Alloy of 47 copper and 53 antimony.
Slightly warm in tint, and crystalline in fracture.

1040. Alloy of 45 copper and 55 antimony.
Like No. **1039.**

1041. Alloy of 40 copper and 60 antimony.
Like No. **1038.**

1042. Alloy of 32 copper and 68 antimony.
A little less warm in tint.

1043. Alloy of 25 copper and 75 antimony.
Tarnishing black, crystalline.

1044. Alloy of 20 copper and 80 antimony.
Irregular plates in an irregular bottom.

1045. Alloy of 10 copper and 90 antimony.

Spotted with dark grey, platy in fracture.

1046. Alloy of 76 parts of copper and 24 of tin.

The total material used was 2,000 grains, and the resulting alloy weighed 1,980 grains, showing a loss of 20 grains or 1 per cent. Experiment by R. Smith. It is yellowish white, and very compact.

1047. Alloy of 2 copper to 1 tin, making "speculum" metal.

Very fine grained, and dead white.

1048. Alloy of 95 copper and 5 tin.

Copper-like, with fibro-crystalline fracture.

1049. Alloy of 90 copper and 10 tin. A bronze.

1050. Alloy of 85 copper and 15 tin. A "bell metal."

Reddish grey, and moderately compact.

1051. Alloy of 80 copper and 20 tin. A "bell metal."

1052. Alloy of 1 part copper and 3 lead.

Much oxidation is shown.

1053. Alloy of 3 parts copper and 1 of lead.

Altogether coated thickly with oxide of lead.

1054. Alloy of copper and zinc.

Obtained in experiments by R. Smith on cementation. The lower portion of the crucible contents consists of malleable brass, and the upper portion of a white brittle alloy. The experiment consisted of melting 461 grains of zinc with a copper penny weighing 285 grains, giving copper 38·20 and zinc 61·8 per cent.

1055. Alloy of copper and zinc.

Obtained by R. Smith, by the cementation of a copper penny weighing 295 grains, with 495 grains of zinc, or copper 37·34, zinc 62·66 per cent. The bottom of the button is bright brass-yellow, the upper part a brittle white metal.

1056. Thin sheet (No. 4 metal gauge) of Dutch metal brass. Sent from this country as rolled brass.

It contains 2 lbs. of copper to 1 lb. of zinc. Communicated by P. Moore.

1057. Two books of Dutch metal in thin sheets.

1058. Alloy of 1 part of copper with 1 part of nickel.

A solid metallic alloy is not formed, and the result is inseparable from the crucible.

1059. Copper amalgam.

A very brittle, easily tarnished, warm white metallic alloy.

1060. Alloy of 98 parts of copper with 2 of gold.

Appears very slightly different from pure copper.

1061. Alloy of copper and aluminium. "Aluminium bronze."

Electro-deposited copper was melted with 2 per cent. of aluminium. The result is extremely tough, files and polishes well, and resembles copper.

1062. Alloy of 95 copper and 5 aluminium from cryolite.

It has a golden colour.

1063. Alloy of 90·7 copper and 9·3 of aluminium.

Partly rolled out into a sheet. Of a light yellow tint.

1064. Alloy of 90 copper and 10 aluminium.

Golden yellow, fracture fibrous.

1065. Alloy of 90 copper, 5 aluminium, and 5 zinc.

Yellowish white, the button has been hammered out.

1066. Alloy of 93·7 copper, 4·5 aluminium, and 1·8 silicon.

Light yellow, crystalline on a filed surface.

1067. Alloy of 95 copper and 5 aluminium.

Of a fine golden colour, the ingot has been hammered and filed.

1068. Alloy of 3 of copper and 1 of tin.

The button is very like copper, but it is full of large black-lined holes.

1069. Alloy of equal parts of copper, antimony, and lead.

Imperfectly united, fracture irregular, colour grey. It has formed distinct metallic globules.

1070. Alloy of 83 copper, 12 tin, and 5 lead, called "Roman pot metal."

Reddish, fracture rough, with some globules.

1071. Roman pot metal, found in Cambridgeshire.

Analysed in 1847.

1072. Alloy of copper, tin, and antimony.

1,540 grains of bean-shot copper, 400 grains of granulated tin, and 60 of best regulus antimony were fused at a loss of 8 grains. Of warmish grey tint, with irregular platy fracture.

1073. Alloy of copper, tin, lead, and zinc.

Analysis gave copper 68·88, tin 8·67, lead 15·89, zinc 6·34, and iron ·42. It is copper-red, with specks of white metal unassimilated. The surface has effloresced with a white powder.

1074. Bronze made directly from Cornish ore, containing a little cassiterite. At Morfa Copper Works, Swansea.

The ore is melted with sharp slag, to get coarse metal, which contains all the tin, and if raised to about 40 per cent. by admixture of refinery slag, or other rich oxidised copper stuff, will deliver the alloy perfectly distinct from the regulus. The specimen has been remelted and cast. Reddish with crystalline fracture. Used for ships' nails. Communicated by W. Terrill.

1075. Copper cobalt alloy from Australia.

Contains copper, iron, nickel, cobalt, and chromium. A rough scoriaceous ingot. Communicated by J. Holworthy, &c.

1076. Alloy of copper and manganese. Patented by Dr. Percy in 1850.

It contains about 30 per cent. of manganese. The lump weighing about 6 lbs. was made with copper, such as was used at the Nickel and Cobalt Works of Evans and Askin, Birmingham, and oxide of manganese precipitated by lime, from a boiling solution of chloride of manganese. A clay pot was heated, and a thin carbon pot was dropped in, and then the copper and oxide of manganese, with more charcoal than sufficed for reduction and the whole heated in a German silver melting furnace. The pot was covered, and a high temperature was used. Reduction of the oxide of manganese was complete. The carbon pot was made of gas retort carbon, mixed with tar ; it was unaltered in appearance by the process. This is accompanied by a MS. with further details of similar alloys, by Dr. Percy.

1077. Alloy of copper and manganese.

The two metals have been in one case fused together under carbon, in the other case by means of a flux composed of a mixture of salt and fluor-spar.

1078. Alloy of copper and manganese.

Contains 15·06 per cent. of manganese and 85·03 per cent. of copper.

1079. Fenton's patent antifrictional metal.

Patent No. 10,208, 1844. This alloy is stated to be not liable to heat or other destructive results caused by friction, and to be of increased durability and of lighter weight than copper or brass. It is made in two stages. 32 parts of copper are melted, and to it are added 1 part of sheet brass, and afterwards 15 parts of block tin. The alloy thus formed is called the hardening metal. In the second stage of the process, 19 parts of zinc are melted under charcoal, to this is added 2 parts of the hardening metal, and after these are well mixed 3 parts of block tin. Communicated by Mr. Bromhead.

1080. Samples of brass intended for railway bearings.

The composition of this brass is—

Copper - - - -	69·33
Zinc - - - - -	25·74
Tin - - - - -	4·39
Lead - - - - -	0·72
Bismuth - - -	trace
	100·18

1081. Brass showing columnar fracture.

Composition unknown. The extreme of the coarse fibro-crystalline fracture.

1082. Series of brasses containing different proportions of copper and zinc.

(1) contains copper 6, zinc 4; (2) scrap copper 7, zinc 4; (3) copper 4, "brass" 1; (4) copper 9, zinc 4; (5) selected copper 7, zinc 4; (6) proportion not known; (8) 3 copper, 1 zinc; (9) 5 copper, 2 zinc. Clifford's Mills, Birmingham.

1083. Muntz yellow metal, broken hot and broken cold.

Showing the difference of fracture: the one broken cold is finely radiate, that broken hot is torn out into coarse shreds. Communicated by W. Edmonds of the Mines Royal.

1084. Brass made by cementation and afterwards remelted.

Copper 78, zinc 22 per cent.

1085. Brass supposed to contain tungsten.

Two fragments of a dish.

1086. Soft French brass.

Said by the Paris manufacturer to contain equal parts of zinc and copper from Swedish ores. It is inelastic as a sheet. Communicated by P. Moore, 1848.

1087. Calamine brass. Birmingham, 1848.

Three qualities showing difference of fracture, all being coarse. Communicated by Mr. Penberth.

1088. Impure brass containing arsenic.

Copper 2, zinc 1, arsenic 1 per cent. of the whole.

1089. Impure brass containing lead.

Copper 2, zinc 1, lead 1 per cent. of the whole.

1090. Impure brass containing antimony.

Copper 2, zinc 1, antimony 1 per cent. of the whole.

1091. Crystallised brass.

From the poured-out interior of a crucible. It shows arborescent crystals forming skeleton octahedra. Communicated by J. Keats, 1849.

1092. Yellow metal broken cold to show the structure which is strongly fibrous.

Contains 38 per cent. of zinc. Morfa Works, 1869.

1093. Specimens of "phosphorus" bronze.

One ingot and one sample of sheathing. Communicated by Colonel Maxwell.

1094. Brass consisting of equal parts of copper and zinc.

1095. Phosphor-bronze.

Contains about 10 per cent. of tin and 1 per cent. of phosphorus. Its tensile strength is reported to be 63,000 lbs. per square inch of sectional area. It is thus especially tough as well as hard. The copper forms a homogeneous alloy with tin phosphide, which prevents the solution of the metallic oxides. Communicated by D. Weston, 1885.

1096. Sample trade specimen of "crown bronze."

Communicated by Thomson, Stone, and Co.

1097. Alloy of copper, antimony, and cobalt.

This is the result of an attempt to separate cobalt from copper regulus (coarse metal) containing about 40 per cent. copper and 3 per cent. cobalt. To this, when oxidised, copper waste was added, and this alloy was obtained as a "bottom." It contains 16·56 per cent. antimony and 6·08 cobalt. It has a white tint. Morfa Copper Works, 1886. Communicated by W. Terrill.

1098. Complex alloy called "arguzoid." Manufactured by Thomson, Stone, and Co. Analysis by R. Smith.

Copper	51·54	51·52 in second sample.
Zinc	15·27	
Nickel	23·94	
Lead	4·33	
Tin	3·21	3·21 in second sample.
Iron	0·64	
Arsenic	traces	
	98·93	

1099. Bronze, cast round a centre of iron, after the manner of the ancient Assyrians.

1100. Specimen of ordinary Chinese brass, cast in a thin sheet. Analysed by J. Philipp, 1855.

Copper	56·59
Zinc	38·27
Lead	3·30
Tin	1·08
Iron	1·47
	100·71

See Percy's Metallurgy, 1861, p. 618. Communicated by Sir H. S. Parkes.

1101. Japanese alloy used for mending native saucepans. Analysed by C. Tookey, 1874.

Copper - - - - -	81·43
Lead - - - - -	9·30
Zinc - - - - -	4·65
Tin - - - - -	4·00
Iron - - - - -	traces
	99·38

1102. Japanese tempo.

Illustrating the casting of Japanese bronze. One specimen is in the form of an oval coin stamped with words, and with a square central hole. The other is an irregular flat rod.

1103. Samples of naval brass bars.

Manufactured at the Morfa Works, Swansea. It is Muntz metal with the addition of 1 per cent. of tin. The fracture is exceedingly fine.

1104. Sheet of naval brass, as put on the "Anson" at Sheerness.

It is made of copper 61, zinc 38, tin 1.

1105. Muntz metal sheathing.

Two specimens as put on the "Anson" at Sheerness. The copper in one is believed to contain a large per-centage of arsenic. Copper 60, zinc 40. Communicated by J. Farquharson.

1106. Muntz metal test assay.

Shows on one side the "rough surface."

1107. Yellow, or Muntz metal, showing peculiar pattern on the surface, due to the copper scale in rolling. Greenfield Copper Mills, Holywell.

Irregular in fracture, and peppered with lighter coloured scales.

1108. Naval brass substituted for Muntz metal in H.M. Navy in 1874.

(1.) A bolt made from a plain rod, and the head forged hot in a machine by one blow. (2.) A sheet rolled hot and cold, as is usual with Muntz metal. (3.) An ingot. (4.) Some ships' nails. This contains a greater proportion of copper and also a little tin. Communicated by the Chatham Officers.

1109. Series of castings of Muntz metal used as a test for the purity of the copper of which it is composed, especially the presence or absence of arsenic.

(1.) Muntz metal made from best selected copper, showing a very fine fibrous fracture. This is what the fracture is when arsenic is absent. (2.) In this slab ·1 per cent. of arsenic has been added to the copper, and the fibre of the fracture has become coarser. (3.) In this ·05 per cent. of arsenic has been added, and the coarseness of the fibre is intermediate. (4.) In this ·05 per cent. of antimony has been added and the effect on the coarseness of the fibre is much greater. (5.) In this there is ·01 per cent. only of antimony, and the fracture is intermediate, but coarser than with ·05 per cent. of arsenic. The test can, therefore, only be applied when antimony is not in question. (6.) This has ·1 per cent. of tin, and this is seen to make an imperceptible difference in the fracture. (7.) This has ·1 per cent. of bismuth, and the effect on the fracture is equally small. The test of fracture does not serve, therefore, for the detection of these metals. Communicated by W. Weston, Portsmouth Dockyard, 1874.

1110. Castings of Muntz metal to test copper of boiler tubes.

Of the three samples (1) contains no arsenic, (2) less than (3), and (3) about ·045 per cent. This is indicated by the comparison of their fractures with those containing definite amounts of arsenic. Communicated by W. Weston, Portsmouth Dockyard, 1874.

1111. Samples of gun metal broken at high temperatures.

(1.) Gun metal containing 83 per cent. copper, 2 of tin, and 15 of zinc, broken at 450° Fahr. (fine radial fibres). (2.) Gun metal containing 88 per cent. of copper, 3 of tin, and 8½ of zinc, broken at 350° Fahr. (irregular fibro-crystalline fracture). (3.) Gun metal containing 87¾ copper, 9¾ of tin, and 2½ of zinc, broken at 300° Fahr. (coarse fibro-crystalline fracture). Communicated by J. Farquharson, Admiralty.

COPPER AND ITS ALLOYS IN USE.

1112. Two bronze medallions.

Of British manufacture, apparently of the 17th century.

1113. Phosphor-bronze pins from the International Exhibition, 1873.

Communicated by A. Dick.

1114. Phosphor-bronze hammer.

1115. Phosphor-bronze chisel.

1116. Phosphor-bronze bread-knife.

1117. Chips from the exterior of a phosphoric "B.L." gun under trial.

These contain 1·9 per cent. of phosphorus. Communicated by Col. C. Maxwell.

1118. Chips from the interior of a phosphoric "M.L." gun under trial.

These contain 1·23 per cent. of phosphorus. Communicated by Col. C. Maxwell.

1119. Top of dead-head of "M.L." phosphoric bronze gun under trial.

This contains 2·3 per cent. of phosphorus. Communicated by Col. C. Maxwell.

1120. Piece of dead-head of phosphoric gun and turnings from the same.

Communicated by Col. C. Maxwell.

1121. Pinchbeck metal made into watch-cases and spoons.

Formerly much used for watches, &c. The larger watch-case contains 90·59 per cent. copper, and the smaller 87·54 per cent. with a small quantity of tin. Determination by W. J. Ward. Obtained from Mr. Baker, of Cranbourne Street.

1122. Speculum metal.

A portion of the material used for Mr. Lassels' four-feet speculum in 1859. It consists of copper and tin alone. The polish obtained on this material in the great speculum was very brilliant and durable, and after six months' exposure retained its lustre as well as any speculum. Communicated by Mr. Lassells, 1859.

1123. Bronze metal used for making the figures on the Wellington funeral car. Stewart and Smith, Sheffield.

1124. Indian brass sheep-bells; cast in a dome-like form.

1125. Hollow vase made of thin beaten copper.

From the Italian Department of the Exhibition of 1862; of an egg-like shape, with a small opening.

1126. Moorish coins.

Containing: copper, 70 per cent.; lead, 24 per cent.; tin, 3 per cent.; and zinc, 3 per cent. Communicated by A. M. Bell.

1127. Old Russian coins.

Made of a very fine quality of copper.

1128. Ancient Indian coins.

Communicated by E. Thomas for analysis. No. 1 is of a very early date, and of the old square form. No. 2 is a cast coin, one of a class extensively current about 300 B.C. No. 3 is a coin of similar character to No. **1129**, in which iron was found; and No. 4 is a variety of the same type.

1129. Copper and iron coin from Delhi.

Communicated by Mr. Thomas. Analysed by C. Tookey. It contains 94·59 per cent. of copper, and 5·06 per cent. of iron. *See* Percy's Metallurgy, 1861, p. 504.

1130. Brass coin of the Emperor Tiberius, about A.D. 33.

1131. Coins from the Duke of Northumberland's collection.

Named by Adm. Smyth, F.R.S. Some analysed by Trenham Phillips (*see* Journal). Second brass coin of Adrian, A.D. 119. Third brass coin of Alexander 2nd, 128–122 B.C. Second brass coin of Demetrius Soter, B.C. 162–150. A large brass Greek Imperial of Philip, junior, A.D. 247. Second brass coin of Vespasian, A.D. 71 (analysed). It contains 81·97 per cent. of copper, 18·68 of zinc, 0·14 of lead, and 0·12 of iron. *See* Percy's Metallurgy, 1861, p. 522. A large brass Greek Imperial coin of Philip, senior, A.D. 245, obliterated coin. Second brass coin, struck at Syracuse, B.C. 275; struck at Alexandria, 180 A.D. Coin of Ptolemy Philadelphus, middle of brass, B.C. 282. Small brass coin of Alexander the Great, B.C. 330 (but it is a forgery). Two second brass coins of Antioch, in Syria. Coin of Aurelian, A.D. 274. Coin of Pyrrhus, King of Epirus, B.C. 276. Small brass Greek coin, about 199 B.C. Coin of Aurelian, about A.D. 270. A third brass coin of Philip the Second of Macedon (doubtful). Second brass coin struck at Antioch, about A.D. 80 (analysed). These are evidence of the early use of brass.

1132. Canadian one-cent piece. Analysed and found to contain 95 per cent. of copper, 4 of tin, and 1 of zinc.

1133. Ancient Pompeian bronze.

A 4½ inch nail, a curtain ring, and fragments. Communicated by C. R. Clarke.

1134. Bronze and copper objects from the ruins of Mycenæ.

Analysed in 1878. Described in Schliemann's "Mycenæ," p. 368, &c.

No. I., II., and III., there described, being silver and gold, will be found under that head.

No. IV. is a portion of a bronze sword, figured at No. 546, p. 372. This is now coated over with several layers, produced by weathering, consisting of carbonate, oxychloride, and red oxide of copper, and peroxide of tin. The metal within is very sound and free from cavities; the fracture is yellowish copper-red, and finely granular.

Its mean composition, as analysed by R. Smith, is—

Copper - - - -	86·36
Tin - - - - -	13·06
Lead - - - - -	0·11
Iron - - - - -	0·17
Nickel - - - -	0·15
	99·85

No. 5 is a fragment of a bronze vase handle, figured as No. 547–9. It is covered with green weathering products. Its analysis by W. J. Ward, gives—

Copper - - - -	89·69
Tin - - - - -	10·08
	99·77

and was therefore exceptionally pure.

No. 6 is a fragment of a copper kettle from the fourth Sepulchre; it is much crumpled, and is from $\frac{1}{25}$ to $\frac{1}{30}$ in. in thickness. There are three rivets, and one rivet hole. The rivets appear to be of the same metal as the kettle. The weathered surface contains oxychloride of copper. The analysis by W. J. Ward gives—

Copper	98·47
Tin	0·09
Lead	0·16
Bismuth	traces
Silver	0·13
Iron	0·03
Nickel	0·19
Arsenic	0·83
	99·90

1135. Piece of a bronze shell made by the Chinese, and thrown into Canton during the first Chinese war.

Communicated by Dr. Lockhart.

1136. Orichalcum.

Melted from ornaments contained in the British Museum. The brass of the ancients containing copper and zinc. *See* Percy's Metallurgy, 1861, p. 526.

1137. Assyrian bronze.

Analysed by Dr. Percy, and found to contain 89·51 copper, and 10·63 tin, with traces of iron.

1138. Piece of Assyrian bronze.

Analysed by Dr. Percy, and found to contain 89·92 per cent. copper, 9·71 of tin, and a trace of iron.

1139. Ancient Assyrian bronze from Nineveh. For analysis.

1140. Bronze spear head from Evesham.

Communicated by J. Gibbs. For analysis.

1141. Fragments of a speculum, and a ring from a Roman burial-ground at Colchester.

They are green from the contained copper. Communicated by J. Taylor.

1142. Piece of Roman shield. Analysed by J. H. Henry.

Contains copper, antimony, cobalt, &c.

1143. Indian anklet of bronze cast in one piece.

This is a flexible ring 4 in. in diameter, made of an endless curb chain of 43 links, cast at a single operation. First, each link is modelled in wax, in its final position, interlocking three other links; each has three knobs, of which one serves as a channel for the metal to enter. Each ring is then separated from the rest by painting it over with a thin coat of fine clay; other coats are added to ½ in. thickness, and a groove is cut at the top down to the knobs. The wax is then melted out, and the metal poured in. The anklet is then inflexible, being attached to the ring, which runs round the groove ; this is then broken off, and the rest becomes flexible. *See* C. P. Clarke. Journal Iron and Steel Institute, 1886. Communicated by Caspar P. Clarke.

1144. Piece of large bronze ring, from Africa ; said to be of native manufacture.

Analysed by J. F. Phillips. Copper, 89·84 ; tin, 10·61 ; zinc, 20 ; lead, 15. Communicated by D. Stranger.

1145. Brass used for gilt spoons, &c.

Analysed by C. H. B. Hambly. Contains : copper, 87·83 ; zinc, 12·44 ; iron, 0·35. *See* Percy's Metallurgy, 1861, p. 621. Communicated by Mr. Tyler.

1146. Bronze casting. The lowest part of the bottom runner, which cooled first.

Very rough and irregular.

1147. Bronze casting. The sow or feeding runner, which cooled last, with a coarse arborescent fracture.

These two specimens show the difference between two portions of the same casting.

1148. Specimen of bronze metal from the tomb of Henry VII. in Westminster Abbey.

1149. Filings off Westminster Abbey gate.

1150. Portion of the first " Big Ben," after it was broken up.

From the Clock Tower of the Houses of Parliament. Communicated by Sir E. Beckett.

1151. Bell of the same composition as " Big Ben."

This bell has become completely cracked at the top, without ever having been rung.

1152. Bronze of which the Peel statute was cast.

Bismuth was added, and was found also by analysis. Cast by Messrs. Robinson, Pimlico.

1153. Parts of one of the lower, and one of the upper, runs of the " Great Bell."

1154. Six specimens of fragments of bell metal from Russia.

Communicated by Sir R. J. Murchison. No further information.

1155. Fragment of " Old Tom," of Lincoln.

Communicated by E. B. Denison, 1860.

1156. Fragment of " Big Ben."

The first that was set up in the Houses of Parliament, Westminster, and which cracked. Communicated by E. B. Denison, 1860.

1157. Fragment of the old Tenor Bell of Doncaster Parish Church.

Set up in 1722. A very fine bell, weighing 30 cwt. Communicated by E. B. Denison, 1860.

1158. Small fragment of the successor of the Doncaster Bell.

A bad bell. Communicated by E. B. Denison, 1860.

1159. Fragment of a Russian bell.

Communicated by Mr. Mears, 1860.

1160. Fragment of a bell manufactured by Mr. Mears.

Communicated by E. B. Denison, 1860.

1161. Fragments of the great bell at Westminster.

Communicated by E. B. Denison. The bell is composed of 7 parts of tin to 22 parts of copper, which were melted together twice, once in pots and secondly in a reverberatory furnace. Some of the tin is probably lost in the process.

1162. Turnings from the crack in "Big Ben" in 1860, at various depths.

1 is from the lower end ; 2, from a depth of 1 inch ; 3, between 1 inch and $2\frac{1}{16}$ inches in depth ; 4, from between $2\frac{1}{16}$ and $2\frac{3}{8}$ inches deep ; 5, from between $2\frac{3}{4}$ inches and 3 inches ; and 6, from beyond 3 inches deep.

1163. The metal of which a Chinese gong has been made, melted and cast into an ingot.

With fragments of the original gong. The metal is brass-yellow and very compact in fracture.

1164. Brass nails made at Portsmouth Dockyard for fixing sheathing.

Contain copper, tin, and zinc, and are not of the same composition as the sheathing.

1165. Fluted brass nails, to be used for fixing ship sheathing.

1166. Fluted brass nails, after they have been used in fixing ship's sheathing.

1167. Iron nails coated with brass.

Communicated by Mr. Fearn, Birmingham.

1168. Alloy of copper and zinc, made according to the composition recommended for ships' nails.

1169. Brass ships' nails in three sets (labelled A, B, C).

1170. Bad ships' nails which rotted and broke off at the heads after a few months' voyage to India.

They contain 52·73 per cent. of copper, 41·18 of zinc, and 4·72 of lead. *See* Percy's Metallurgy, 1861, p. 516.

1171. Ships' nails off the bottom of a ship after a voyage of eighteen months to India and back.

Analysed and found to contain 62·62 per cent. of copper, 24·64 of zinc, 8·69 of lead, and 2·64 of tin. *See* Percy's Metallurgy, 1861, p. 516.

1172. Samples of nail heads that have come off owing to the defective composition of the ships' nails.

With a nail made after the composition in use at the Government Dockyards in 1858. Communicated by C. Clifford.

1173. Bad brass ships' nails, showing where they have failed.

Their heads have corroded off, where the inside of the sheathing has been pushed into the wood in driving them in.

1174. Brass tube which has been six years in use in the "Ruby" engine.

1175. Brass tube which has been in use in the "Acis" engine, till replacement was necessary.

1176. Deposit formed in the brass tube during use in the "Acis" engine.

It is a dark green powder, changing to bright green.

1177. Brass tube which has been in use in the "Thistle" engine for about eighteen months.

It is a little choked internally with a green dusty deposit.

1178. Brass tube which has been in use in the "Sittingbourne" engine, till replacement was necessary.

1179. Sample of brass metal cock analysed for the Admiralty in 1877.

The material for analysis was taken from the portion between the two remaining pieces. No. I. from the inlet part, No. II. from the outlet part ; with the following result :—

	I.	II.	Mean.
Copper - -	88·04	87·49	87·76
Tin - -	3·59	3·59	3·59
Zinc - -	5·44	5·50	5·47
Arsenic - -	0·63	0·65	0·64
Lead - -	2·44	2·44	2·44
Iron - -	0·14	0·16	0·15
Antimony - -	trace	trace	trace
Manganese - -	trace	trace	trace
Nickel - -	trace	trace	trace
	100·28	99·83	100·05

1180. Sample of old Muntz metal sheathing, showing very great corrosion.

Taken off May 1875. Communicated by Mr. H. Wiggin.

1181. Piece of ornamental brass work, made by punching on the upper surface.

The piece of brass is laid and fixed on another piece of brass, which lies on a solid bed. The design is fashioned by punching the surface of the brass in the depressed portions, whereby the prominent portions are left in relief. Commonly worked at Keswick, where the specimen was procured, 1885.

DEFECTS AND WEARING OF BRASS.

1182. Brass wire which has become brittle by keeping for about one year.

Communicated by Mr. Ward.

1183. Screw bolt from the propeller of H.M.S. "Frederick William."

Propeller fixed in 1860, removed in 1875; showing state of bolt.

1184. Defective brass casting.

The surface appears quite sound, as is seen where the brass has not been turned, but as soon as it is turned minute specks and holes appear. It is thought by some to be due to the metal and not to the casting, there being too much "dust" metal, as brass filings, &c., employed in its manufacture. *See* Percy's Metallurgy, Copper, 1861, p. 622. Communicated by T. C. Salt, 1849.

1185. "Spuey brass" in the form of a foliated ornament.

This has the characteristic defect of green spots on the surface after lacquering. The acid liquor used in dipping previous to lacquering gets into minute cavities just below the surface, but opening on to it by a narrow passage, so that the acid cannot be completely washed off. After lacquering the acid breaks through in time and causes the green spots. *See* Percy's Metallurgy, 1861, p. 622. Communicated by T. C. Salt, 1849.

1186. Defective brass. Splits on bending into rings.

Communicated by Francis Clarke, Birmingham, 1848.

1187. Defective brass. Breaks on twisting.

Communicated by Francis Clarke.

1188. A piece of brass which cannot be annealed.

It has been nearly seven hours at a heat nearly sufficient to melt it without being softened when cooled.

1189. A piece of copper, requiring only a slight blow of a hammer to break it like glass.

1190. Arm of a brass gas pendant, which broke of its own accord and fell in Mr. Prim's sitting-room, Houses of Parliament, 1869.

1191. Undulating markings on brass, produced in rolling.

Probably by the jerking of the rolls at Clifford's Mills, Birmingham, 1848.

1192. Defective brass, splitting along the centre.

Made from bad copper from Burra-Burra ore. Communicated by P. Moore.

1193. Brass ship-bolt, showing highly crystalline fracture.

Communicated by Mr. Hughes, of Keats and Co., 1867.

1194. Molecular change in Muntz metal.

The outer part of the bolt has become separated from the inner, which stands out by itself. This change is produced by constant strain. *See* Percy's Metallurgy, 1861, p. 621.

1195. Samples showing the breaking up of the surface of Muntz's metal under the action of sea water.

In one case where it has been cracked in rolling, in the other where the bolt has been strained. In both cases there is a distinct surface-layer of a brown rough fracture. This portion on analysis shows 90 per cent. of copper, the original brass having only 60 per cent. The lost zinc appears to have been dissolved out as a chloride by the sea water. From the condenser of the "Active" after 10 years' use. The naval brass is not found to be acted on in the same manner. Communicated by A. Musson of the Admiralty, 1881.

1196. Brass made with bad copper from Burra-Burra ore, 1848.

It becomes "frog-mouthed" on rolling. A sample of the ore contained antimony. Communicated by P. Moore, Birmingham, 1848.

1197. Result of bad copper being used in brass making.

When the brass is rolled it splits into rough sheets, which part asunder. Communicated by P. Moore, 1848.

1198. Tubes which have become brittle from lying about.

They have been kept near the ceiling in a room in which gas was burning, and in which acid chemicals were often slightly escaping. They cannot be restored by annealing. Communicated by B. P. Walker, 1869.

1199. Action of organisms on Muntz metal in sea water.

The tube is from the condenser of the Orontes, and the hole was found under a barnacle, such as here accompany it. Possibly only due to the water lodging there. Communicated by A. Musson of the Admiralty, 1881.

1200. Samples of broken screws showing the molecular changes in Muntz metal under strain.

From the "Bullfinch." Described in M. Farquharson's report to the Admiralty. The outer part has decayed away, and left only a small cylinder of sound brass in the centre. *See* Percy's Metallurgy, 1861, p. 621.

1201. Part of an old ship's rudder-band having the appearance of copper, but made really of Muntz metal.

It has lost its colour, weight, and tenacity, yet is only Muntz metal cast in a sand mould. Communicated by F. Bleiber, Handsworth, Birmingham, 1885.

1202. Old Muntz metal remelted.

The casting has been made from the pieces of old sheathing accompanying it, which will bend. The melting was done very carefully, and the result is a metal of a bright yellow colour like that produced by 7 of copper to 4 of zinc. It actually contains 36·36 per cent. of zinc. Communicated by F. Bleiber.

1203. Old Muntz metal remelted.

Each piece that was remelted in this case was rotten and brown in fracture (like No. **1201**), but on remelting carefully a metal is produced of a deep yellow colour equal to that of 7 best selected copper to 3 of zinc. The old pieces accompany the casting. Communicated by F. Bleiber.

1204. Gun-metal casting, split in the middle.

There are seen two distinct layers of metal, which in some cases can be separated as if they had never been joined, though poured from the same crucible. It is suggested that this is caused by the metal flowing into the mould to the furthest end, and then welling up and turning back over the lower part, and thus each ingot consists of two currents in opposite directions cooling at different times. This will not happen if the metal is poured quickly or very hot, or the castings are upright. Communicated by F. Bleiber.

1205. Samples of Muntz metal bolts, showing a central core.

These pieces show a difference in lustre of the central core, before it has been acted on by the sea water, showing that the defect is in the original casting. If a bolt be rolled from an ingot divided into layers as No. **1204**, and one of these is enclosed within the other and then drawn out, there will be a cylindrical line of separation, and the sea water will attack the bolt where the cohesion is weakest. Communicated by F. Bleiber.

1206. Fine brass castings, showing the "sere" where broken.

These consist of 70 parts of copper, 40 of zinc, and 1 of lead, carefully melted and run into ingots, and then used in casting. The casting is liable to "sere" if the best copper and zinc are not used. Communicated by F. Bleiber.

1207. Piece of old sheathing, worn very thin, but yet retaining its toughness and original colour in the fracture.

Communicated by C. Clifford, 1860.

1208. Old sheathing, very little worn, but retaining no toughness and become red in the fracture.

The metal which thus becomes red and rotten seldom wears thin. Communicated by C. Clifford.

1209. Sheathing honeycombed in wear.

This has made two voyages to Australia, and has lain in the London Docks whilst in port. It retains its toughness and original colour of fracture. The peculiarity is not due to imperfect mixture of the metals, for they were well stirred. It may be the water of the London Docks. Communicated by C. Clifford.

1210. Sheathing prevented from weathering by paint.

Communicated by C. Clifford.

1211. Bolt that has been in a ship's timbers six years.

It shows a different core in the centre, even where not corroded, and in one case this core has different diameters at one end and the other, showing it is conical and original. Communicated by C. Clifford.

1212. Copper sheathing honeycombed on the surface in the same way as the Muntz metal sheathing.

Communicated by C. Clifford.

1213. Muntz metal sheathing which has been preserved from decay by the action of the nails.

The sheathing is sound and of its original thickness round the nail holes, though worn away and honeycombed elsewhere. Communicated by C. Clifford.

1214. Old yellow metal sheathing.

This has been on the "San Fernanda," of Sutherland, for 2½ years on three voyages to Chili and back. Communicated by J. Nicholson, 1860.

1215. Old yellow metal sheathing.

On for four years on West Indian and Chilian voyages. Communicated by J. Nicholson.

1216. Old yellow metal sheathing, showing corrosion of the surface.

Taken from the "Calphurnia," 1863. Communicated by J. Nicholson.

SPECIAL APPLICATIONS OF COPPER.

1217. Glass coloured with red oxide of copper.

It shows a beautifully crystalline structure under the microscope. It is manufactured near St. Petersburg. Specimens were exhibited in the Exhibition of 1862. There is a fine specimen in the Slade Collection in the British Museum.

1218. Opaque glass filled with minute separate copper scales, giving it a red colour.

Communicated by Mr. Matthews.

1219. Glass coloured red by copper oxide.

Perfectly transparent.

1220. Glass "flashed" with a fine layer of copper glass.

From Messrs. Chance's Works, Birmingham. The copper glass is opaque at a distance, the red colour by reflected light preventing the passage of the transmitted light, which is seen to be green when the glass is held to the light.

1221. Copper deposited in the interior of an incandescent lamp.

A fifty-candle Edison lamp. It very rarely happens that such a copper deposit is formed. The copper is vaporised when the greatest resistance in the circuit happens to be at the copper junction of the carbon film and platinum wire. This lamp shows the vertical line of no deposit, or shadow of the carbon film which indicates that the particles of copper are ejected in straight lines from the heated junction. The deposited copper when thin enough is seen to be green by transmitted light. *See* Fleming, Phil. Mag., July 1883, p. 48. Communicated by him.

1222. Glass containing oxides of copper and iron.

The tear-like piece shows two colours, the one red, produced by gently heating and slowly cooling, the other green, produced by strongly heating and rapidly cooling. *See* Percy's Metallurgy, 1861, p. 351.

ZINC.

Experiments.

1223. Result of heating one equivalent of zinc with two of litharge.

160 grains of zinc in fine powder were heated with 1,120 grains of litharge, in a well-covered clay crucible to a strong red heat for three quarters of an hour. The result is a button of malleable lead, weighing 245 grains, and an imperfectly fused slag of dark brown colour.

1224. Result of heating together two equivalents of zinc and one of galena.

An imperfectly metallic porous mass, not thoroughly fused.

1225. Zinc heated with phosphorus.

Said to give it a more silver-like colour.

1226. Result of heating one equivalent of zinc oxide with one of boracic acid.

200 grains of zinc oxide were fused with 175 grains of boracic acid in a platinum crucible, to strong redness in a muffle for half an hour,

and poured into an open ingot mould. The result is a colourless transparent glass, slightly opalescent on the surface, with conchoidal, non-crystalline fracture. *See* Percy's Metallurgy, 1861, p. 538.

1227. Result of heating two equivalents of zinc oxide with one of boracic acid.

240 grains of zinc oxide were fused with 105 grains of boracic acid in the same manner as the last. The result is a white, vitreous, crystalline, translucent solid, with a large lamellar fracture and pearly lustre. *See* Percy's Metallurgy, 1861, p. 538.

1228. Result of heating three equivalents of zinc oxide with one of boracic acid.

240 grains of zinc oxide were fused with 70 grains of boracic acid in the same manner as before. The result is vitreous, pale yellow, and opaque in mass, but translucent in small pieces. The fracture is less largely lamellar, and the lustre less pearly. *See* Percy's Metallurgy, 1861, p. 538.

1229. Result of heating three equivalents of oxide of zinc with two of boracic acid.

240 grains of oxide of zinc were fused with 140 grains of boracic acid in the same manner as before. The result is a beautiful transparent glass, with no trace of crystallisation. Experiments by R. Smith. *See* Percy's Metallurgy, 1861, p. 538.

1230. Result of heating one equivalent of zinc oxide with one of silica.

200 grains of zinc oxide were heated with 230 grains of fine Australian sand of great purity, in a Cornish crucible placed in a muffle during five hours to a strong heat at or near whiteness. The product is fritted only and not melted. *See* Percy's Metallurgy, 1861, p. 536.

1231. Result of heating two equivalents of zinc oxide with one of silica.

240 grains of zinc oxide were heated with 138 grains of the same sand, under the same conditions as the last. The product is fritted, but not so firmly as the last. *See* Percy's Metallurgy, 1861, p. 536.

1232. Result of heating three equivalents of zinc oxide with one of silica.

240 grains of zinc oxide were heated with 92 grains of the same sand, under the same conditions as before. The product is fritted more than the last. *See* Percy's Metallurgy, 1861, p. 536. Experiments by R. Smith.

1233. Result of heating together four equivalents of zinc and one of arsenic.

132 grains of zinc were heated with 75 grains of arsenic in a glass test tube. They combined with a red glow at a temperature considerably below a red heat, forming a porous mass of peculiar fracture and submetallic lustre. It was not changed by subjecting it to a good red heat in a covered crucible, but at a bright red heat was volatilised. *See* Percy's Metallurgy, 1861, p. 547.

1234. Result of heating zinc with 10 per cent. of arsenic.

This produces no glow when heated, but the result has a similar fracture, rather more coherent. *See* Percy's Metallurgy, 1861, p. 547.

1235. Zinc and arsenic.

Result of stirring pulverised arsenic with melted zinc. One portion remained fluid in the centre, the remainder became a very porous solid mass. Samples of both are here. The solid portion is crystalline, so that an arsenide of zinc appears to be formed. Experiment by R. Smith.

1236. Zinc and arsenic.

A hard scum of peculiar bluish lustre, and smelling strongly of arsenic.

1237. Crystals obtained by exposing zinc oxide and zinc sulphide to a white heat in a Cornish crucible.

They are minute, obscure, brownish-yellow crystals incrusting the crucible. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 541.

1238. Zinc oxide heated with alumina on platinum foil.

One equivalent of zinc oxide was mixed with six equivalents of anhydrous alumina in a small crucible of platinum foil, enclosed in a covered and luted clay crucible. It was heated for an hour in Deville's furnace; the result is a compact, grey, stony substance which scratches glass. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 539.

1239. Result of heating zinc oxide in a blende-lined crucible.

The clay crucible was filled with Laxey blende in powder solidly rammed down, closed with well-luted covers, and strongly heated for half an hour. A cavity was made in the blende, thus firmly agglutinated, and 40 grains of zinc oxide were inserted and the remainder filled with powdered blende. The crucible was enclosed in a plumbago crucible, and heated to white heat for an hour. The cavity which had been filled with zinc oxide is now quite empty, the blende is much acted on here, and the clay crucible below the cavity is coloured blue. The cover of the clay crucible is coated with small brown crystals. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 542.

1240. Result of heating a mixture of zinc oxide and zinc sulphide in a blende-lined crucible.

20 grains of oxide of zinc were intimately mixed with 92 grains of Laxey blende, *i.e.* in the ratio of one equivalent of zinc oxide to three of zinc sulphide. The mixture was treated in the same way as in No. **1239.** A light porous crystalline residue (contained in the glass-capped box) was found in the blende cavity. This is the weight that ought to be left if the zinc oxide and sulphide combined to form zinc and sulphurous acid. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 542.

1241. Result of heating zinc oxide and zinc sulphide in a blende-lined crucible.

40 grains of zinc oxide were mixed with 48 grains of zinc sulphide, *i.e.* in the ratio of one equivalent of zinc oxide to one of zinc sulphide,

and treated in the same way as in No. **1239.** A light porous residue weighing 22 grains is left, the proper balance from the reaction being 24 grains. The crucible cover is again lined with brown crystals. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 542.

1242. Result of exposing sulphide of zinc to a high temperature.

200 grains of Laxey blende free from matrix were very strongly heated in a small Stourbridge clay crucible in Deville's furnace during 1½ hours, with anthracite. The crucible was covered with various other crucibles. The blende has become firmly agglutinated, though not fused, into one mass, and has lost nine grains in weight. On the upper part of the crucible is seen some dark crystalline matter of a somewhat metallic lustre. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 540.

1243. Result of heating sulphide of zinc with tin.

96 grains of pulverised Laxey blende and 116 grains of granulated tin were exposed together in a covered clay crucible to a bright red heat during half an hour. A metallic button weighing 14·5 grains has been produced. It is harder than tin, but has been flattened considerably under the hammer, but not without slightly cracking at the edges. Its fracture is crystalline-granular, and it has nearly the colour of tin, but contains zinc. This is covered by an easily separable regulus weighing 11 grains. It is hard, brittle, finely granular in fracture, and iron-grey in colour. The internal surface of the crucible is not acted on, nor is it permeated. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 543.

1244. Result of heating sulphide of zinc with antimony.

A mixture of 144 grains of Laxey blende and 120 grains of antimony was prepared by trituration, and exposed in a covered clay crucible to a bright red heat during half an hour. The product consists of an agglutinated and firmly coherent mass weighing 245 grains, thereby showing a loss of 19 grains; it is easily fractured, and shows a uniform mixture of particles of blende and a well-melted metal resembling antimony; in certain lights a cleavage with a brillant metallic lustre is shown. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 543.

1245. Result of heating sulphide of zinc with lead.

A mixture of 192 grains of pulverised Laxey blende and 416 of finely granulated lead was exposed in a covered clay crucible, at a bright red heat during three quarters of an hour. The product is an imperfectly fused cavernous mass, hard, brittle, largely crystalline, dark lead-grey, and metallic in lustre. The internal surface of the crucible has been acted on and covered with a brown porous substance. No metallic lead is seen. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 543.

1246. Result of heating sulphide of zinc with copper.

A mixture of 48 grains of Laxey blende with 128 grains of powdered copper was exposed in a covered clay crucible to a bright red heat during half an hour. The product consists of a button of metal and regulus. The metal resembles brass in colour and fracture, and weighs 85 grains. The regulus resembles sulphide of copper, and weighs

71 grains. This shows a reduction of the zinc. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 544.

1247. Fragments of crucibles used in the above experiments.

They show crystals in various spots.

1248. Result of heating oxide of zinc with iron.

80 grains of zinc oxide were intimately mixed with 56 grains of iron wire in very small pieces, and heated in a wrought-iron crucible at a very high temperature for one hour within a French pot. The result is a mass of iron and a black glassy slag. In the exterior crucible is a dark green glass, as if the wrought-iron pot had leaked. Experiment by R. Smith. *See* Percy's Metallurgy, 1861, p. 536.

1249. Result of fusing together three equivalents of silicate of zinc of the formula $3\ ZnO\ .\ SiO_2$, with one equivalent of borate of zinc of the formula $3\ ZnO\ .\ BO_3$, in a platinum crucible at a white heat.

This is equivalent to introducing 5·37 per cent. of boracic acid. One result is a translucent greenish-white glass.

ZINC ORES.

1250. Laxey blende.

The sulphide of zinc, obtained at Laxey, and used at Hafod. Pounded to small fragments.

1251. Calamine or carbonate of zinc, in a transparent crystalline form.

1252. Calamine from Sweden.

As used at the Vieille Montagne Works, Belgium, for the manufacture of Belgian zinc. In a brown, earthy form.

1253. Silicate of zinc.

From Bethlehem, Pennsylvania, U.S.A. In a stalactitic form.

1254. Artificial blende or sulphide of zinc.

From the Muldner Hütte, Freiberg. An incrustation on the surface of the roasting furnaces.

1255. Franklinite, an oxide of zinc, iron, and manganese.

From New Jersey Mining Company, Newark. Communicated by H. Bauerman. After calcination it is treated as an iron ore.

1256. Franklinite, from New Jersey.

An oxide of zinc, iron, and manganese. Used first for the extraction of zinc, and the residue smelted for manganiferous iron.

PRODUCTS OF THE OPERATIONS FOR THE EXTRACTION OF ZINC.

1257. Calcined blende mixed with coke ready for distillation.

Vivian's Works, 1848 In small fragments.

1258. Calcined blende, without coke.

Vivian's Works, 1848. In small fragments.

1259. Calcined calamine.

From Llansamlet Spelter Works, Swansea, 1869. The inner part has an incrustation of rhombic white crystals, which are radially arranged about numerous points.

1260. Incrustation on the inner surface of the top of Silesian zinc pot.

This is an arborescent yellow mass of crystalline oxide of zinc. One specimen shows brilliant crystal faces. Communicated by Messrs. Dillwyn, 1859.

1261. Fragment of zinc pot, from an old English zinc furnace.

From Mines Royal Works, 1869. Shows a scoriaceous scum on the surface of the blue-purple pot, which is coated with a fused brown substance within.

1262. Concretion of oxide of zinc formed by leaving the pot in the furnace.

A curved shell-like mass of consolidated powder of white oxide, showing a radiating and concentric structure, coated with loose powder within. Communicated by Mr. Clifford, Fazeley Street Mills, Birmingham.

1263. Zinc from the internal surface of a condensing tube in the English process.

Vivian's Works, Morriston, Swansea, 1848.

1264. Piece of spelter pot, impregnated with zinc and thus rendered purple to a certain depth.

This will be used over again wish fresh Stourbridge clay in making new pots.

1265. Piece of old spelter pot, impregnated with zinc and associated substances.

It looks purple and scoriaceous.

1266. Portion of an old Belgian zinc retort.

Used at the Spelter Works, Dee Bank. Showing two layers; the inner the edge of the fused contents, the outer the impregnated pot of purple colour with unaltered siliceous fragments.

1267. Microscopic section of a Silesian zinc retort, from Lipine, Silesia.

Showing the formation of zinc spinel. *See* Freiberg Jahrbuck, 1881. Communicated by H. Bauerman.

1268. Mammillated crystalline zinc oxide.

From the bottom of a spelter pot at Mines Royal Works, 1859, where spelter was then obtained by the English process. Communicated by W. Edmonds.

1269. Zinc oxide incrustation, as a greenish-white crystalline stalactite.

From the New Jersey White Zinc Works. *See* Am. Journ. Sci., vol. 13, p. 417.

1270. Powdered oxide of zinc.

From Hafod Zinc Works, 1848. This is produced in the Silesian and Belgian processes. *See* Percy's Metallurgy, 1861, p. 586.

1271. "Grey oxide of zinc."

Collected from the neck of the retorts at Alston Works. Communicated by G. Attwood.

1272. Zinc fume.

From the Alston Works. Contains 49·92 of zinc. Communicated by G. Attwood.

1273. Tube of oxide of zinc formed on a cupel in which zinc was heated in a muffle.

Produced at the Metallurgical Laboratory, Jermyn Street, 1880. The cupel on which it was formed accompanies it. It has a very close resemblance to a long coral from the chalk, possessing both longitudinal furrows and transverse lines of growth. The furrows, however, sometimes bifurcate and sometimes reunite. The tube is quite hollow, and has a crater-like top, free from any radial grooves.

1274. Zinc fumes, called "Blue oxide."

From Vivian's Spelter Works, Morriston, Swansea, 1883. Contains zinc in a finely divided state, mixed with its oxide.

1275. Consolidated zinc fumes, from the Zinc Works of Laurium, Greece.

Showing columnar formation. Grey oxide within coated with white oxide.

1276. Consolidated zinc fumes from Laurium, Greece.

Showing a fine and contorted columnar formation. Grey oxide coated with white oxide.

1277. Scoria from the distillation of zinc.

Hafod Zinc Works, 1848.

1278. Residium of the zinc pots.

Vivian's Works, Swansea. An earthy, dark, crumbling mass.

1279. Refuse from the spelter pot.

After the zinc has been distilled away, all the non-volatile material in the ore or in the coke is left as an open mass in the bottom of the pot. This is chiefly derived from the triturated ore. It is fragmental in structure.

1280. Slag from spelter pot.

This is another variety of the same refuse derived more directly from the fuel. It resembles a purple coke.

1281. Spelter dross.

Heated to a very high temperature in an open pot, then with a perforated ladle the sediment is removed from the bottom of the pot. Rylands' Works, Warrington. A mass of grey metallic crystals of prismatic form. Communicated by F. Dixon.

1282. Spelter dross.

The refuse of the hard spelter, after it has been in a closed pot and heated so high as to drive off all the spelter. It is a mass of beautiful iridescent grey, rhombic metallic crystals. Mostly of prismatic form. Communicated by F. Dixon.

1283. Crystallised zinc oxide.

From the New Jersey, U.S.A., White Zinc Works. From Professor G. J. Brush, Yale College. Long, greenish, transparent needles.

1284. Iridescent crystals in zinc.

Formed on heating zinc which had been accidentally mixed with dross and refuse in the ash-pit. Rylands' Works, Warrington. These are very like the crystals of No. **1282.** Communicated by F. Dixon, 1873.

METALLIC ZINC.

1285. Zinc made from silicate ores.

Minerva Works, Wrexham. It is very tough, and not so bright as that made from blende or oxide ores, but the grain is good. Communicated by G. Darlington.

1286. Zinc produced by the old English process.

Hafod Works, Swansea, 1848. Largely crystallised.

1287. Zinc from the Warrington Galvanising Works.

Bank Quay, Warrington, 1873. Very brilliant narrow crystals. Communicated by F. Dixon.

1288. Sheet zinc rolled cold.

1289. Finely granulated zinc.

1290. Zinc showing a very large crystalline cleavage.

Communicated by C. Tookey.

1291. Sample of zinc showing a finely lamellar crystalline fracture.

Communicated by F. A. Dixon, Warrington, 1873.

1292. Zinc melted at a low temperature under carbon, and cooled slowly.

It is a granular mass, but each granule is globular and smooth, and more or less adherent to the neighbouring ones, the whole forming an arborescent pseudo-crystallisation.

1293. Hollow conical forms of zinc.

Produced by dropping melted zinc into water. The cones have undulating surfaces.

1294. Commercial zinc recrystallised.

The zinc has been melted in an earthen pot, and allowed to cool slightly; then the surface broken and the still fluid contents in the centre poured out.

1295. Zinc containing 1·46 per cent. of lead.

Communicated by Muntz and Co.

1296. Impure zinc.

Contains 0·17 per cent. of iron, and 1·26 per cent. of lead. Analysis by R. Smith. Communicated by Muntz and Co.

1297. Zinc free from arsenic.

1298. Zinc specially prepared pure.

By the chemist at the works of Messrs. Rylands Brothers, Warrington. Shows a broad and brilliant cleavage.

1299. Zinc perfectly free from iron.

Prepared by R. Smith. Analysed by C. Tookey.

1300. Zinc redistilled and free from iron.

1301. An ingot of the first zinc produced in Finland.

Produced from Finnish ore—the original silver-lead-zinc blende, by means of wood, turf and sawdust as fuel. Made by Finnish workmen in part, at Aminne, Pojo, south coast of Finland, the only spelter works in North-East Europe, 1879. Communicated by Mr. Julin.

1302. Chinese zinc from the province of Yunan.

Brought by Sir Harry Parkes. The fracture is platy, but very irregular and spotted.

1303. Zinc which has been in a steam boiler for six weeks.

At the Rhys Las Works, Dowlais, South Wales. It is now entirely brittle, and has for the most part been converted into red oxide, the innermost parts only being grey.

1304. Samples of manufactured zinc.

Perforated examples.

1305. Samples of zinc tubing with galvanised iron roofing.
Communicated by F. Braby.

ALLOYS OF ZINC.

1306. Zinc containing sodium.

It has been fused at a low temperature, in an iron crucible under salt. It has a whiter, more compact, and granular fracture than zinc alone.

1307. Alloy of two equivalents of zinc with one of tin.

1,475 grains of tin were fused with 1,622 grains of zinc; the compound has therefore 52·42 per cent. of zinc. It has a brilliant platy fracture.

1308. Alloy composed of one equivalent of antimony to three of zinc.

It has been melted in a crucible to which it firmly adheres. It has a brilliant bluish-white fracture, soon tarnishing, but not crystalline. The surface has numerous crystalline plates crossing each other. Two specimens. Communicated by Mr. Keats, of Bagillt Lead Works.

1309. Pump-barrel metal.

Consisting of 44 parts of zinc, 44 of tin, and 12 of antimony per cent. The fracture is small and granular, with occasional small flakes.

1310. Zinc and lead.

Commercial zinc melted with about 2 per cent. of lead, well stirred and cooled rapidly by removing the crucible and its contents from the furnace and plunging it into cold water. The lead does not mix, but is found collected at the lower surface. Experiment by R. Smith, 1856.

1311. Alloy of zinc and antimony.

Fused in a crucible. Made by Professor Josiah Cooke, Junior, of Harvard College, Cambridge, U.S.A., in the laboratory of the Royal School of Mines. It adheres to the sides of the crucible as a solid metallic mass below, its surface having large long dull iridescent crystals in form like antimony.

1312. Alloy of 96·1 per cent. of zinc, and 2·6 per cent. of iron.

Has a curious laminated transverse fracture.

1313. Alloy of zinc and iron from Gospel Oak Works, Staffordshire.

Remelted and cooled; it differs very little in appearance from plain zinc, but it is hard and duller, and contains 3 per cent. of iron and a little lead. *See* Percy's Metallurgy, Iron and Steel, p. 154.

1314. Alloy of iron and zinc produced experimentally.

A hard compact mass, of grey tint and conchoidal fracture.

1315. Zinc containing 1·64 per cent. of iron.

Shows a dull and irregular fracture.

1316. Alloy of zinc and iron.

Fused with sulphur and cast into an ingot, like No. **1319.** It shows the same spotted fracture.

PRODUCTS OF THE PROCESS OF "GALVANISING" IRON WITH ZINC.

1317. Alloy of zinc and iron.

This alloy has been produced in the process of galvanising iron. The result is a mass of small elongated rhombic crystals, similar to those of No. **1319.** It contains 9·4 per cent. of iron. Communicated by T. H. Henry, Gospel Oak Works, Birmingham. *See* Percy's Metallurgy, Iron and Steel, p. 155.

1318. Spelter dross, from Rylands' Galvanised Iron Works, Warrington.

This is the ferriferous material that forms in the spelter bath, heated to a very high temperature in an open pot, then with a perforated ladle the sediment is removed from the bottom of the pot, the holes allowing the liquid metal to pass through. This is an alloy of iron and zinc, and consists of minute examples of the same iridescent crystals as in No. **1282.** Communicated by W. Dixon.

1319. Alloy of iron and zinc in an ingot.

Produced in the process of galvanising as above. It is remelted and cast into these small square ingots, which are exported to India. Rylands' Galvanised Iron Works. The fracture is very irregular and platy, with numerous minute black spots. Communicated by F. Dixon.

1320. Alloy of zinc and iron.

Produced in the galvanising process at the Arsenal, Woolwich, 1875. These are very well-formed rhombic prisms, with double pyramidal ends as in No. **1282.** They are all of small size. Communicated by Mr. Charles.

1321. Alloy of zinc and iron, from Gospel Oak Works, Staffordshire.

Obtained in galvanising iron. Contains about 5 per cent. of iron. This is in a solid mass, showing more needle-like crystals than the others, so far as it is separate.

1322. Zinc from among the bricks round a galvanising bath.

One example shows a fine hair-like product, matted together, and having the general aspect of zinc, the rest are platy and brilliant. Communicated by F. Dixon, of the Galvanised Iron Company, Warrington.

1323. Residue from distilling ferriferous zinc lumps obtained in the process of galvanising iron.

Rylands' Galvanising Works, Warrington. An impure earthy-looking mass, probably consisting of iron oxide mixed with zinc and iron alloy. Communicated by F. Dixon.

LEAD.

THE PROPERTIES OF LEAD EXPERIMENTALLY ILLUSTRATED.

1324. Octahedral crystals of lead.

Shown on the surface of glass which was being coated with lead in the process known as "quicking," by which the glass is made into a mirror. The glass is placed in a tray and heated to above the melting-point of lead, and melted lead is poured into the tray, and afterwards drained off. This specimen was produced by the lead accidentally being allowed to stay too long and to partially solidify. *See* Percy's Metallurgy, Lead, p. 1. Made by Mr. Matthews, of Birmingham.

1325. Lead wire, to show its feeble ductility.

Communicated by P. Moore.

1326. Granulated lead, after exposure to the atmosphere.

It has been entirely converted into sub-oxide, by the increase of its bulk by the absorption of oxygen. It burst the wooden box in which it had been contained.

1327. Litharge or protoxide of lead, which has been fused in a crucible.

1328. Litharge crystallised on metallic lead.

This lead has been exposed to the joint action of air and water, which produced colourless transparent crystals of protoxide of lead, having the form of rhombic dodecahedra with truncated acute angles, and on heating in a tube they have become opaque and orange-coloured. *See* Yorke, Phil. Mag., 1834, p. 83; and Percy's Metallurgy, Lead, p. 14. Communicated by Colonel Yorke.

1329. Litharge passing into carbonate of lead.

1330. Litharge melted and coloured by cuprous oxide.

A brownish black glass.

1331. Result of heating together copper sulphide with five times its weight of protoxide of lead.

400 grains of copper sulphide were mixed with 2,000 grains of litharge in covered crucible, and heated for about 10 minutes at a temperature just sufficient to effect perfect fusion. The result is a button resembling lead weighing 410 grains, and containing 5·5 per cent. of copper, together with a slag of the two metallic oxides. Experiment by W. Baker. *See* Percy's Metallurgy, 1861, p. 261.

1332. Result of heating together equal parts of white lead and oxychloride of lead.

It is a greenish-yellow crystalline mass.

1333. Result of heating together 750 parts by weight of litharge with 250 parts of oxychloride of lead.

It is a brownish-yellow crystalline mass.

1334. Result of heating copper sulphide with 20 times its weight of protoxide of lead.

100 grains of copper sulphide were heated with 2,000 grains of litharge, and a button of metal was produced weighing 394 gains. It resembles lead, but contains 5·8 per cent. of copper. Experiment by W. Baker. *See* Percy's Metallurgy, 1861, p. 261.

1335. Result of heating 15 parts of litharge with one of red hæmatite.

A liver-coloured crystalline mass. Experiment by J. F. Davis.

1336. Result of heating eight parts of litharge with one of red hæmatite.

A darker-coloured solid mass, without obvious crystals. Experiment by J. F. Davis.

1337. Result of heating four parts of litharge with one of red hæmatite.

A dark compact mass, except in the centre, in which are minute black crystals.

1338. Result of heating three parts of litharge with one of red hæmatite.

A black mass with a crystal-lined cavity in the centre.

1339. Result of heating two parts of litharge with one of red hæmatite.

A black semi-porous mass.

1340. Result of heating four equivalents of litharge with one of arsenious acid.

99 grains of arsenious acid were fused with 448 grains of litharge in a closed crucible. The product is compact homogeneous, wax-like, opaque and pale orange colour, with a button of lead weighing 28 grains. Hence the arsenious acid has not been to any appreciable extent converted into arsenic acid. Experiment by R. Smith. *See* Percy's Metallurgy, Lead, p. 18.

1341. Result of heating together one equivalent each of litharge and white arsenic.

112 grains of litharge were fused at a dull red heat with 91 grains of white arsenic. The result is an opaque egg-yellow glass.

1342. Result of heating four equivalents of litharge with one of antimony.

194 grains of antimony in powder were fused with 672 grains of litharge in a covered crucible. The product is a brittle button of

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impure lead weighing 374 grains, and a glassy amber-coloured slag. Experiment by R. Smith. *See* Percy's Metallurgy, Lead, p. 19.

1343. Lead reduced by antimony.

500 grains of native antimony, 600 grains of sulphate of lead, 300 grains of nitre, and 300 grains of carbonate of soda were fused together. A button of lead was obtained weighing 70 grains, together with this crystalline slag of antimoniate of lead and soda, which has since decomposed on the surface. Experiment by R. Smith.

1344. Result of heating together three equivalents of oxide of lead and one of tin.

840 grains of lead oxide and 148 grains of granulated tin were taken. The result is not homogeneous, but contains some reduced lead.

1345. Result of heating two equivalents of litharge with one of iron.

140 grains of iron filings were fused at a bright red heat with 1,120 grains of litharge. The product is a button of lead weighing 530 grains, containing only a trace of iron, and a compact, semi-vitreous, dark brownish-black magnetic slag with shots of lead. Experiment by R. Smith. *See* Percy's Metallurgy, Lead, p. 21.

1346. Result of fusing three equivalents of litharge with one of silica.

Melts at a comparatively low temperature, to an orange-coloured glass. Experiment by Dr. Beck. *See* Percy's Metallurgy, Lead, p. 29.

1347. Result of fusing two equivalents of litharge with one of silica.

Melts easily to a bright yellow glass. Experiment by Dr. Beck. *See* Percy's Metallurgy, l.c.

1348. Result of fusing two equivalents of litharge with one of silica.

In this case the product was allowed to cool slowly in the furnace. The result is a green-grey compact mass, with a coating of semi-transparent green glass on the surface. Experiment by Dr. Beck. *See* Percy's Metallurgy, l.c.

1349. Result of fusing three equivalents of litharge with two of silica.

Melts easily to a dark orange-yellow glass. Experiment by Dr. Beck. *See* Percy's Metallurgy, l.c.

1350. Result of fusing one equivalent of litharge with one of silica.

Melts easily to a light yellow glass. Experiment by Dr. Beck. *See* Percy, l.c.

1351. Result of fusing one equivalent of impure litharge with one of silica.

In this case the litharge contained traces of iron and copper, and the result is a transparent green glass. Experiment by Dr. Beck. *See* Percy's Metallurgy, l.c.

1352. Result of fusing two equivalents of litharge with three of silica.

This required a rather high temperature for its fusion, but the result is a yellow glass. Experiment by Dr. Beck. *See* Percy's Metallurgy, l.c.

1353. Result of heating one equivalent of litharge with two of silica.

This required a high temperature for reaction, but fritted into a compact, white, opaque, porcelain-like mass. This has been remelted at a still higher temperature, and poured out rapidly: a glass is thus with difficulty formed. Experiment by Dr. Beck. *See* Percy's Metallurgy, l.c.

1354. Result of heating one equivalent of litharge with four of silica.

At a very high temperature this was fritted into a compact porcelain-like, nearly white mass, very slightly porous. Experiment by Dr. Beck. *See* Percy's Metallurgy, l.c.

1355. Result of heating one equivalent of litharge with six of silica.

This is an opaque porous mass, white with a greenish tinge. Experiment by Dr. Beck. *See* Percy's Metallurgy, l.c.

1356. Result of heating one equivalent of litharge with 12 of silica.

This has been fritted in a white porous mass, scarcely cohering. Experiment by Dr. Beck. *See* Percy's Metallurgy, l.c.

1357. Silicate of lead from red lead and sand.

Two equivalents of red lead were fused in platinum with one of silica. The result is a white powder. Experiment by R. Smith.

1358. Hollow globules obtained by heating silicate of lead with charcoal.

The silicate is made by uniting one equivalent of litharge with one of silica; it is intimately mixed with excess of charcoal powder, and strongly heated in a covered Cornish crucible. No button of lead is formed, but the result is a number of small hollow globules, of white or light yellowish-brown colour, opaque and vitreous, in fracture, and studded with small shots of lead. Experiment by Dr. Beck. *See* Percy's Metallurgy, Lead, p. 31.

1359. The same hollow globules mounted as microscopic objects.

1360. Silicate of lead containing one equivalent of lead oxide to one of silica.

5,000 grains of litharge were fused with 2,034 grains of sand. The result was a not very fluid green glass, which poured without difficulty at a very bright red heat. Experiment by Mr. Gibbs.

1361. The same silicate with some of the sand uncombined.

1362. Silicate of lead containing three equivalents of lead oxide to two of silica.

6,000 grains of litharge were fused with 1,628 grains of sand. This was more fluid than the last and poured more easily. It is a green glass, on account of the impurity of the litharge. Experiment by Mr. Gibbs.

1363. Silicate of lead containing two equivalents of lead oxide to one of silica.

5,000 grains of litharge were fused with 1,017 of sand. The result is a green glass, very fluid at a bright red heat. Experiment by Mr. Gibbs.

1364. The same silicate with purer litharge.

In this case the glass is bright orange-coloured.

1365. Silicate of lead containing three equivalents of lead oxide to one of silica.

5,000 grains of litharge were fused with 678 grains of sand, and the product is a deep orange glass, very fluid at a bright red heat. Experiment by Mr. Gibbs.

1366. Results of experiments on the reduction of silicate of lead by iron.

The silicate of lead, containing two equivalents of lead oxide to one of silica, was prepared by heating red lead with fine sand in a platinum vessel, at a temperature sufficient to frit but not to melt the mass. The temperature was afterwards raised to fuse it. When solid, the product was of an amber colour (*a*). It was poured, and 3,000 grains were heated in a wrought-iron crucible placed for protection against reduction in a clay crucible: at full redness lead began to separate, and the result was soft lead (*b*); 2,212 grains, and a black largely crystalline slag; (*c*) 1,418 grains: 1,115 grains of this slag were remelted in the same iron crucible for an hour, from which 13 grains of lead were obtained; and a crystalline slag (*d*) was left. This slag contains—

Protoxide of iron - - -	68·25
Sesquioxide of iron - - -	2·57
Protoxide of lead - - -	0·82
Silica - - - -	28·36
	100·00

Experiment by R. Smith. *See* Percy's Metallurgy, Lead, pp. 34 and 533.

1367. Lead and galena fused together and cooled slowly.

These were fused together in proportions of one equivalent each. The lead is found at the bottom of the mass, the galena at the top, but there is no very clear line between them. *See* Percy's Metallurgy, Lead, p. 39.

1368. Lead and galena fused together and cooled rapidly.

The product is apparently homogeneous, intermediate in character between the two ingredients. *See* Percy's Metallurgy, Lead, p. 39.

1369. "Subsulphide of lead."

In a dark coloured crystalline ingot. One half of the ingot has been heated to very low redness, without any lead sweating out of it.

1370. Result of heating sulphate of lead with lead.

One equivalent of each yielded two equivalents of lead oxide. 760 grains of sulphate of lead were melted in an earthen crucible with 520 grains of finely granulated lead. The result is a small button of lead weighing 52 grains, and a dark amber-coloured glass, probably silicate of lead. Experiment by R. Smith. *See* Percy's Metallurgy, Lead, p. 45.

1371. Result of heating sulphate of lead with iron.

1,000 grains of the sulphate were heated to bright redness in a wrought-iron crucible, with the addition of iron nails. The result is a button of 520 grains of lead, out of the 681 grains contained in the sulphate. There is left 1,173 grains, dark coloured, imperfectly melted scoriaceous slag. Experiment by R. Smith. *See* Percy's Metallurgy, Lead, p. 45.

1372. Result of heating one equivalent of sulphate of lead with one of sulphide of lead.

In this case the sulphur and oxygen in the ingredients are in the proper proportion to form sulphurous acid which is evolved, and a residue of metallic lead is left. *See* Percy's Metallurgy, Lead, p. 46.

1373. Result of heating three equivalents of sulphate of lead with one of sulphide of lead.

In this case the sulphur can combine with only two thirds of the oxygen present, and protoxide of lead is left as a residue. *See* Percy's Metallurgy, Lead, p. 46.

1374. Result of heating one equivalent of sulphate of lead with two of carbon.

The carbon forms carbonic dioxide with the oxygen, which is evolved, and the residue consists of sulphide of lead. Experiment by R. Smith. *See* Percy's Metallurgy, Lead, p. 51.

1375. Subsulphate of lead produced by fusing together one equivalent of lead sulphate with one of litharge.

760 grains of lead sulphate and 560 grains of litharge were taken. The result is a yellow sub-crystalline solid. Experiment by R. Smith.

1376. Result of heating one equivalent of sulphate of lead with one of carbon.

Carbonic dioxide and sulphurous acid is given off and lead is left. 760 grains of sulphate of lead were fused with 30 grains of carbon, and the result is a button of lead weighing 105 grains, and a glassy amber-coloured slag probably silicate of lead, derived from the crucible. Experiment by R. Smith. *See* Percy's Metallurgy, Lead, p. 52.

1377. Result of heating one equivalent of sulphide of lead with two of protoxide of lead.

In this case the sulphur and oxygen in the ingredients are in the proportion to form sulphurous acid which is given off, and the residue left is lead. 560 grains of litharge were fused with 300 grains of galena, and there is a residue of 576 grains of metallic lead. Experiment by R. Smith. *See* Percy's Metallurgy, Lead, p. 45.

1378. Result of heating one equivalent of sulphide of lead with one of protoxide of lead.

In this case the same reaction takes place, but half the sulphide is left unchanged in the midst of the reduced lead. 560 grains of litharge were fused with 600 grains of galena, and the resulting button weighed 962 grains. These resulting numbers both show great loss of lead. Experiment by R. Smith. *See* Percy's Metallurgy, Lead, p. 46.

1379. Result of heating sulphide of lead with hæmatite and carbon.

200 grains of hæmatite, 420 grains of galena, 35 grains of charcoal, were heated under 100 grains of salt. The result is a button of lead, covered by a dark glass, and this by an earthy slag. Experiment by R. Smith.

1380. Galena reduced by iron.

The contents of the crucible after fusion are a button of lead at the bottom, and a metallic slag, covered with a glassy film.

1381. Impure sulphide of iron produced in assaying lead ores in an iron dish.

See Percy's Metallurgy, Lead, p. 108.

1382. Result of heating together one equivalent of sulphide of lead with two of tin.

The result is a button in two layers. The upper one very thin, crystalline, brittle, but yielding like talc, and friable. The lower one is easily cut with a knife, and shows a highly crystalline structure, with broad cleavage planes, and a blacker colour than galena, more like protosulphide of tin. Experiment by A. Dick, 1855. *See* Percy's Metallurgy, Lead, p. 59.

1383. Result of heating together one equivalent of sulphide of lead with two of tin.

This is the same experiment as No. **1382**, repeated on a larger scale, by R. Smith. 3,700 grains of galena were heated with 3,480 grains of tin. The result is very similar, showing the cleavage planes of the mass well. A small button of lead was also found at the bottom. *See* Percy's Metallurgy, Lead, p. 60.

1384. Result of heating together one equivalent of sulphide of lead with one of copper.

These were heated in a covered crucible, and when fused consisted of two layers. The upper one is a brittle regulus, with a fine-grained bluish-grey fracture; the lower one, soft malleable lead, containing 0·88 per cent. of copper. Experiment by R. Dick. *See* Percy's Metallurgy, Lead, p. 60.

1385. Result of heating together five equivalents of galena with one of zinc.

The mixture was heated in a covered plumbago crucible, and covered with small pieces of charcoal. The product is crystalline, of deeper colour than galena. There was a small button of lead at the bottom. Experiment by R. Smith. *See* Percy's Metallurgy, Lead, p. 61.

1386. Result of heating sulphide of lead with antimony.

The product is homogeneous, and powders before the knife; it is largely crystalline, and has a granular cleavage. There are air-holes, where it has been in contact with the crucible. The pieces of charcoal on the top are coated here and there with crystals of galena. This result shows that galena is not reduced when heated with antimony. Experiment by J. C. Cloud. *See* Percy's Metallurgy, Lead, p. 62.

1387. Result of experiment showing reduction of arsenite of lead.

650 grains of protoxide of lead, 495 grains of arsenious acid, and 60 grains of carbon, when heated together, produce a metallic button of lead, containing arsenic, weighing 380 grains, and capable of being beaten out. Experiment by R. Smith. The product of heating together the litharge and arsenious acid before adding the carbon is an opaque orange-yellow glass, as recorded by Percy's Metallurgy, Lead, p. 18.

1388. Result of heating together galena and phosphate of lead.

119·5 grains of galena and 182·5 grains of phosphate of lead were heated in a covered crucible, and left to cool slowly. The result is in two layers, the upper is of phosphate of lead, which is crystalline, and dirty green in colour, the lower of galena. There is, therefore, no reaction between these bodies at a high temperature. Experiment by J. C. Cloud. *See* Percy's Metallurgy, Lead, p. 76.

ORES OF LEAD.

1389. Coarse crystallised galena from Devonshire.

Contains 79 per cent. of lead and 4 oz. 15 dwt. 9 gr. of silver per ton. Communicated by Sir. L. Palk.

1390. Fine-grained galena from Devonshire.

Contains 51 per cent. of lead and 2 oz. 5 dwt. 8 gr. of silver per ton. Communicated by Sir Lawrence Palk.

1391. Fine-grained galena from Cornwall.

Communicated by Mr. Garby.

1392. Galena from Gogham Lead Mines, near Aberystwith.

Contains 30 oz. of silver per ton.

1393. Coarse galena from the New Red Sandstone, at Garendon, near Charnwood Forest.

This is an accidental occurrence as an isolated mass ; not a vein. It is coarsely crystalline, and contains 81 per cent. of lead and 1 oz. 12 dwt. silver per ton.

1394. " Steel ore " from Snailbeach Mines, Shropshire.

Communicated by Mr. Eddy. It is very fine-grained, compact pure galena, having somewhat of the lustre of fractured steel.

1395. "Blue stone" from North Wales.

A complex ore, obtained at Pary's Mountain, Anglesea, containing sulphide of lead and sulphide of zinc, intimately mixed. *See* Percy's Metallurgy, Lead, p. 405.

1396. Coarse galena from Hornachos, Province of Badajoz, Spain.

1397. Coarse galena and blende intermixed, from Welkenradt, Belgium.

Shows a concretionary structure in the gangue.

1398. Galena from the Val-Sassam Mines.

Contains 58 per cent. of lead and 49 oz. of silver per ton.

1399. Coarse galena from Arrayanez Mine, Linares, Province of Jaen, Spain.

1400. Granular galena from Ems, Nassau.

1401. Coarse galena, called " Potters' ore," or " Glazur-Erz."

From Blei Alf, Rhenish Prussia.

1402. Coarse galena from Portugal.

1403. Coarse galena from Saila, Sweden.

Contains 75·2 per cent. of lead and 0·769 per cent. of silver = 281 oz. 4 dwt. to the ton ; also traces of gold.

1404. Lead ore from Dickenlie Mines, Turkey.

Contains 77 per cent. of lead and 11 oz. 11 dwt. 12 gr. of silver per ton. In small fragments. Communicated by E. M. Ward.

1405. Complex lead ore from Turkey.

Contains 37 per cent. of galena, 20 per cent. of blende, 20 per cent. of iron pyrites, and 23 per cent. of quartz, yielding 32 per cent. of lead, 13·16 per cent. of zinc, and 0·0218 of silver, equal to 7 oz. 2 dwt. 10 gr.

per ton of ore. A rough irregular veinstuff. Communicated by Mr. Bateman.

1406. Galena disseminated in conglomerate.

From the Lower Trias, Mechernich, Rhenish Prussia.

1407. Galena disseminated in sandstone.

From the Lower Trias, Mechernich, Rhenish Prussia.

1408. Galena from Australia imported to England.

Used at the Llanelly Lead Works, 1886. Said to be rich in silver, *i.e.*, from 50 to 100 oz. per ton. A sparry ore.

1409. Fine-grained galena from Dhamauri Mine, near Subathu, India.

1410. Galena from Magna Mine, near Subathu, India.

A brown gravelly ore.

1411. Carbonate of lead, "cerussite," from the Morning Star Mine, Leadville, Colorado. Crystallised.

1412. Carbonate of lead, "cerussite," from the Evening Star Mine, Leadville, Colorado. Massive.

The next 25 specimens are from the Emma Mine, Utah. They are all worked for lead and silver, and the assays are estimated from the ton of 2,000 lbs. All of them are communicated by G. Attwood.

1413. Coarse galena, containing 75 per cent. lead and 1,151·82 oz. silver per ton.

1414. Galena, containing 64 per cent. lead and 165·24 oz. silver per ton.

1415. Galena with associated copper ore, contains 56 per cent. lead and 123·93 oz. silver per ton.

1416. Galena and cerussite, contains 68 per cent. lead and 140·93 oz. silver per ton.

1417. Galena and wall, contains 62 per cent. lead and 626·93 oz. silver per ton.

1418. Mixed ore, contains 70 per cent. lead and 69·25 oz. silver per ton.

1419. Mixed ore, contains 63 per cent. lead and 267·3 oz. silver per ton.

1420. Light carbonate (?) with copper, contains 73 per cent. lead and 2,741·04 oz. silver per ton (?).

1421. Mixed ore, contains 74 per cent. lead and 685·26 oz. silver per ton.

1422. Cerussite with copper, contains 61 per cent. lead and 68·04 oz. silver per ton.

1423. Mixed ore, contains 70 per cent. lead and 908·82 oz. silver per ton.

1424. Mixed ore, contains 70 per cent. lead and 68·04 oz. silver per ton.

1425. Cerussite, contains 68 per cent. lead and 1,992·64 oz. silver per ton.

1426. Impregnated breccia, contains 74 per cent. lead and 68·04 oz. silver per ton.

1427. Surface gossan, contains 33 per cent. lead and 1,081·35 oz. silver per ton.

1428. Coppery gossan, containing 39 per cent. lead and 1,105·84 oz. silver per ton.

1429. Ferruginous gossan, contains 24 per cent. lead and 112·99 oz. silver per ton.

1430. Impregnated breccia, contains 20 per cent. lead and 36·45 oz. silver per ton.

1431. Coppery gossan, contains 20 per cent. lead and 399·73 oz. silver per ton.

1432. Cerussite breccia, contains 14 per cent. lead and 48·60 oz. silver per ton.

1433. Gossan, contains 6 per cent. lead and 6·07 oz. silver per ton.

1434. Weathered breccia, contains 6 per cent. lead and 13·39 oz. silver per ton.

1435. Surface breccia, contains 5 per cent. lead and 82·62 oz. silver per ton.

1436. Impregnated washings, contain 4 per cent. lead and 10·93 oz. silver per ton.

1437. Lower limestone wall of the lode.

1438. General sample of the silver-lead ores from Utah, imported into this country.

Taken at Liverpool in 1871 from a cargo sent for smelting at Dee Bank.

1439. Series of samples of lead ores called "linnets," from the Alport Smelting Works, Derbyshire.

There are seven samples, of which five are called carbonates and two called phosphates, but all of them "linnets," owing to their colour. They are all in small fragments. Two of these samples, apparently Nos. 1 and 7, have been analysed by R. Smith. No. 1 is a carbonate, and contains only a trace of phosphoric acid; it yields 24·6 per cent. of lead, and ·0025 per cent. of silver, 56·6 per cent being insoluble in acids. No. 7 contains 2·62 per cent. of phosphoric acid, corresponding to 16·7 per cent. of phosphate of lead; it yields a total of 35·1 per cent. of lead, and there is 41·83 per cent. insoluble in acids. *See* Percy's Metallurgy, Lead, p. 433.

1440. Mixed Flintshire lead ores.

Ground and prepared for smelting at the Bagillt Lead Works, Flintshire.

1441. Mixed pounded ores ready for smelting at the Dee Bank Lead Works, Holywell.

Communicated by A. B. Dick.

1442. Lead ore prepared for use at the Snailbeach Lead Works, Shropshire.

Communicated by Eddy and Sons.

1443. Coarse-ground galena from Snailbeach Lead Mines.

1444. Lead ore as prepared for use in the reverberatory furnace at Alport Lead Works, Derbyshire.

1445. Powdered galena.

As used in the ore-hearth furnace of the Keld Head Lead Works Wensleydale, North Yorkshire.

1446. Waste ores as smelted in a double-bedded reverberatory furnace at Keld Head Lead Works.

Communicated by W. Weston.

1447. Superior slime ore, pounded.

As smelted in the double-bedded reverberatory furnace at Keld Head. Slime ore is Dr. Percy's name for the fine dust which is separated from the coarser ore, and which requires special precautions in smelting to prevent its being carried away. *See* his Metallurgy, Lead, p. 360.

1448. Poor slimes.

Grey powder, roasted in reverberatory furnace and smelted in the slag hearth.

1449. Best ore, as smelted on the ore hearth.

At the Keld Head Lead Works, near Leyburn, Yorkshire. Communicated by W. Weston.

1450. Crystallised cerussite.

From the Hæmatite Mines, Sydney, New South Wales.

1451. Sulphate of lead, an Australian ore.

This is imported into England for smelting at the Bagillt Works, Holywell (1859). Analysed by Smith and Ward, 1870. *See* Percy's Metallurgy, Lead, p. 430.

Sulphuric acid	20·66
Protoxide of lead	42·34
Oxides of iron	18·93
Silver, &c.	0·84
Water combined	3·48
Insoluble residue	13·09
Earths and non-metals	1·44
	100·78

Contains 39·30 per cent. lead, 132 oz. 6 dwt. 19 grains silver per ton.

ILLUSTRATIONS OF LEAD SMELTING.

1452. Roasted ore, previous to pulverisation. Dee Bank Lead Works, 1859.

1453. Calcined ore, previous to pulverisation. Dee Bank Lead Works, 1859.

1454. Galena roasted for 2½ hours.

It is then gradually reduced to small fragments.

1455. Ore calcined for two hours in a reverberatory Flintshire furnace.

From Newton, Keats, and Co.'s Lead Works, Bagillt, Holywell. Analysed by W. Weston.

Sulphide of lead	Lead	46·57	53·79
	Sulphur	7·22	
Sulphate of lead	Protoxide of lead	2·09	2·84
	Sulphuric acid	0·75	
Protoxide of lead			36·87
Oxide of zinc			2·65
Lime			1·63
Protoxide of iron			0·90
Silica			1·10
			99·78

See Percy's Metallurgy, Lead, p. 239. A loosely aggregated powder.

1456. Ore calcined for three hours in a reverberatory Flintshire furnace.

From Newton, Keats, and Co.'s Lead Works, Bagillt. Analysed by W. Weston.

Sulphide of lead	Lead	47·23	54·56
	Sulphur	7·33	
Sulphate of lead	Protoxide of lead	5·64	7·67
	Sulphuric acid	2·03	

Protoxide of lead - - -	27·18
Oxide of zinc - - -	5·19
Lime - - - - -	1·96
Protoxide of iron - - -	1·33
Silica - - - -	1·85
	99·74

See Percy's Metallurgy, Lead, p. 239. A loosely aggregated powder.

1457. Charge after setting up previous to pulverisation. Dee Bank Lead Works, 1859.

1458. Grey earthy slag from smelting galena. Dee Bank Lead Works, 1859.

1459. Grey slag from the ores of the district. Dee Bank Lead Works.

A rough brown semi-scoriaceous mass.

1460. Skimming from the Flintshire furnace.

This is taken from the surface of the lead towards the end of the smelting process. It has been remelted in a crucible. From Newton, Keats, and Co.'s Works, Bagillt. It is dark and sub crystalline.

1461. Black glassy slag for crushing and washing.

This is "clean slag" from the blast furnace. It is crushed and washed to separate the intermixed spots of metallic lead. The remainder is thrown away. From the Bagillt Works. Analysed by W. Weston.

Silica - - - - -	33·94
Alumina - - - -	13·00
Lime - - - - -	20·70
Protoxide of lead - - -	10·64
Protoxide of iron - - -	12·34
Oxide of zinc - - - -	8·78
	99·40

See Percy's Metallurgy, Lead, p. 420.

1462. Skimming of furnace pot.

From the Flintshire furnaces of the Dee Bank Lead Works. It is black, pulverulent, and crystalline.

1463. Grey slag from Cornish ores of high assay.

This slag may contain from 40 to 50 per cent. of lead, and from 5 to 8 oz. silver per ton. From the Dee Bank Lead Works. A grey crystalline rough slab with large vertical holes. Communicated by A. B. Dick.

1464. Scum from the surface of the furnace pot.

From the Flintshire furnace at Walker, Parker, and Co.'s. Containing most of the impurities of the lead. An irregular, heavy, scoriaceous black mass. Communicated by A. B. Dick.

1465. Slag from the slag hearth.

From the Flintshire furnace at Alport, Derbyshire. Black and glassy, broken to small fragments.

1466. Run slag from the reverberatory furnace.

From Alport Lead Works, Derbyshire. The composition of such a slag is given in Percy's Metallurgy, Lead, p. 241, but not of this sample. It is light coloured and strong, with tube-like holes.

1467. Drawn slag from the reverberatory furnace.

From Alport Lead Works, Derbyshire. The composition of such a slag is given in Percy's Metallurgy, Lead, p. 241, but not of this sample. It is grey and stony.

1468. Run slag.

From Llanelly Lead Works. A blue glassy slag, having the surface tinged with red.

1469. Black crystalline slag from the breast pan of the slag hearth.

From the Lead Works at Alport, Derbyshire.

1470. Grey slag.

A crystalline stony mass, weathering brown. From Newton, Keats, and Co.'s Works, Bagillt.

1471. Mean sample of grey slag.

Ground to a powder. It may contain 50 or 55 per cent. of lead, and 1 or 2 oz. of silver per ton of lead. Walker, Parker, and Co.'s Lead Works.

Experiments made at the Lead Smelting Works, Alston, to ascertain if scorification removes foreign metals or other impurities from slag lead, 1848.

1472. Scoria from slag lead kept melted during four hours with access of air.

It is now heavy and dark.

1473. Scoria from slag lead kept melted during eight hours with access of air. Nenthead Lead Works, Alston.

It is now dark and cavernous.

1474. Scoria from slag lead kept melted during 12 hours with access of air. Nenthead Works.

It is now light and irregular.

1475. Grey slag from smelting best ore.

At the ore-hearth furnaces at Keld Head Mines, Wensleydale, Yorkshire. It is massive and earthy. Communicated by W. Weston.

1476. Slag from slag hearth in smelting inferior ore.

Keld Head Works, Yorkshire. In small dull black fragments.

1477. Pounded white slag from ore hearth.

The portion that passed through a sieve of 60 to the inch. Communicated by W. Weston.

1478. White slag from ore hearth.

The lead, &c. which is retained by the $\frac{1}{60}$-inch sieve; 452 grains out of 5,512 grains is thus retained. Communicated by W. Weston.

1479. Slags from smelting calcined Utah ores in a flowing furnace.

From Dee Bank Lead Works, 1871. One is a black compact slag, glassy on the surface. The second is more slaggy, and the third, which is oxidised, is red in colour.

1480. Slag from smelting Australian sulphate ores.

Produced at the Bagillt Smelting Works. *See* Percy's Metallurgy, Lead, p. 431. It is dull black and massive, with a few cavities.

1481. Matt from smelting Australian sulphate ores.

From this the lead is obtained by two roastings and smeltings. *See* Percy's Metallurgy, l.c. It is a heavy sub-metallic dark slab.

1482. Slag from Australian lead ore.

From the smelting of an earthy ore in a water-jacket furnace, 1886. It consists of brilliant black plates like those of silicate of iron. Communicated by F. M. Drake.

1483. Slag from Australian lead ore.

From a furnace in continual work where the object is the extraction of gold from pyrites with the use of as little lead as possible. It consists of brilliant interlocking acicular crystals. Communicated by F. M. Drake.

1484. Slag from Australian argentiferous lead ore.

Smelted in a water-jacket furnace. It shows striated rhombic prisms like those of silicate of iron. Communicated by F. M. Drake.

1485. Lead slag with metallic lead found at Alston Moor.

Supposed to have been produced in Roman lead works.

1486. Lead slag with pieces of charcoal imbedded in it, from Alston Moor.

Supposed to have been produced in Roman lead works. It was found under cover of three feet of soil and turf near Bowgill Barn, a short distance from the Roman Road, in the Manor of Glassonby.

1487. Lead slag from old lead works at Loe Pool, Falmouth.

It is compact and black, and slightly scoriaceous.

1488. Slags from lead smelting used in "sweep" smelting.

The "sweeps" are the residues in gold and silver works, which are smelted with lead slags, &c. to recover the more precious metals. The history of these specimens is rather doubtful.

ACCIDENTAL PRODUCTS.

1489. Red lead formed in the bed of a reverberatory furnace, at the Dee Bank Lead Works, 1871.

A crumbling cake. Communicated by A. B. Dick.

1490. Red lead formed in a smelting furnace.

From the Alport Lead Works, Derbyshire.

1491. Lead and red lead found in an old reverberatory furnace at Pontesford, Shropshire.

Found about 2 ft. 4 in. below the level of the surface of the working furnace bed, below the slags and below part of the brickwork. This furnace was not built on a double arch as is now done, and yielded when broken up and revived about 11 tons 3 cwts. 3 qrs. of refined lead. Communicated by Mr. Eddy.

1492. Silvery micaceous litharge.

Found in taking up the bed of a calciner at the Llanelly Lead Works, 1859. Communicated by Mr. Williams.

1493. Deposit which forms in the flues of the litharge furnaces.

At Benson's White Lead Works, Birmingham. It is stalactitic in form, red inside, and grey and crumbling outside.

1494. Yellow micaceous litharge.

From the bed of the lead calcining furnace at Nenthead, Alston.

1495. Crystallised sulphide of lead.

Formed in the bed of a reverberatory furnace at the Dee Bank Lead Works, 1871. It is now disintegrated. Communicated by A. B. Dick.

1496. Crystallised product from the smelting furnace at Dee Bank Lead Works.

The crystals in the cavity are micaceous and may be litharge.

1497. Concretions under the test of a cupellation furnace.

From Gossage's White Lead Works, Birmingham, 1841. They are long complex stalactitic masses of decayed lead.

1498. Microscpic slide of crystalline litharge.

From the base of a calciner at the Llanelly Lead Works, South Wales.

1499. Artificially crystallised sulphide of lead.

Brilliant hopper-shaped crystals, forming an incrustation from a lead smelting furnace, at Regla, near Real del Monte, 1846. Communicated by Mr. Broomhead, of Birmingham.

1500. Artificially crystallised sulphide of lead.

A furnace product from the Wahsatch Smelting Works, U.S.A. Some of this shows a purple lamina due to the intermixed metallic impurities.

The crystals are not well formed, but appear to be cubic. Communicated by Mr. Blackwell.

1501. Concretion from the protoxide furnace.

Formed in the production of lead in the dry way, by oxidising the ore in a reverberatory furnace. From Messrs. Atkins' Works.

PATTINSON'S PROCESS FOR THE EXTRACTION OF SILVER FROM LEAD.

1502. Specimens of hard lead from slag smelting.

Nos. 1, 2, and 3, of different hardness, previous to submission to Pattinson's process. Communicated by H. L. Pattinson, 1849.

1503. The original lead put into the fourth pot.

It contains 9 oz. 16 dwt. silver per ton of 21 cwt.

1504. The first crop of crystals obtained from the fourth pot.

These contain 4 oz. 4 dwt. 16 gr. silver per ton of 21 cwt.

1505. The second crop of crystals obtained from the fifth pot.

These contain 2 oz. 7 dwt. silver per ton of 21 cwt.

1506. The third crop of crystals obtained from the sixth pot.

These contain 1 oz. 3 dwt. 12 gr. silver per ton of 21 cwt.

1507. The fourth crop of crystals obtained from the seventh pot.

These contain 10 dwt. 23 gr. silver per ton of 21 cwt.

1508. The melted lead from the market pot.

Called "horn lead," being the melting of the crystals obtained from the seventh pot, and containing only 10 dwt. 23 gr. silver per ton of 21 cwt.

PARKES' PROCESS OF DESILVERISATION.

1509. Piece of Belgian retort, after use in smelting the lead.

1510. Argentiferous zinc crust, taken off the molten lead.

From the Llanelly Lead Works, 1859. This contains most of the silver in the lead, viz., 275 oz. 8 dwt. per ton. *See* Percy's Metallurgy, Lead, p. 152.

1511. First skimming of the molten lead, after taking off the crust.

From the Llanelly Lead Works, 1859.

1512. Lead liquated out of the zinc crust.

This contains 55 oz. of silver per ton, but should not contain more than 10 oz. *See* Percy's Metallurgy, Lead, p. 152.

1513. Portion of the zinc crust, after the lead has been liquated out of it.

1514. Zinc distilled from the liquated zinc, and cast in the form of a bar.

1515. The silver powder left as a residue, after the zinc has been distilled off.

An earthy grey powder containing the silver.

1516. Slag from the run-down silver powder.

It is massive, compact, and cavernous.

These are all (Nos. **1509-16**) from the same process as carried on at the Llanelly Works in 1859.

1517. Zinc alloy taken from the lead in Parkes' process.

This has been subsequently liquated to withdraw a portion of the lead. It now has the composition—

Silver	3·13
Lead	73·42
Copper	2·07
Arsenic	3·49
Antimony	0·19
Zinc	16·84
Iron	trace
Insoluble residue	0·25
	99·39

Analysed and communicated by J. G. Hochstatter, at Par Smelting Works, Cornwall, 1870. In small earthy lumps.

1518. Lead rich in silver after distilling off the zinc.

This is a further stage of the same process. From the Par Smelting Works, 1870. Communicated by J. G. Hochstatter.

1519. Zinc containing silver from the skimmings of the zinc alloy.

From the Par Smelting Works. In a fine powder called "scum powder."

1520. Dross from the softening furnace.

This is produced in the treatment of the lead contaminated with zinc. It contains the impurities after the lead has been softened by Parkes' process. From the Llanelly Lead Works, 1859. *See* Percy's Metallurgy, Lead. It is heavy, scoriaceous, and earthy-looking.

1521. Ingot of desilvered lead now ready for the softening furnace in Parkes' process.

From the Llanelly Lead Works, 1859.

1522. Ingot of lead after softening.

This has had the impurities partially removed (*see* No. **1518**) by heating in the softening furnace, and is now ready for the poling pot. From the Llanelly Lead Works, 1859.

1523. Desilvered softened lead after poling.

This is the softened lead tapped off from the softening furnace into a cast-iron receiver, where it is "boiled" or poled by submerged wood, and is now ready for the market. From the Llanelly Lead Works, 1859.

CORDURIÉ'S PROCESS.

1524. Oxide from near the charging door of the silver blast furnace in Cordurié's process.

This is produced in the dezincification of lead by steam, passed through the molten mass, whereby the impurities and part of the lead are oxidised, and blow away as powder. It contains 17·85 per cent. of lead, and 37 oz. 11 dwt. of silver to the ton. From the Par Smelting Works, 1870. Communicated by J. G. Hochstatter.

1525. Powdery deposit in the chimney, in Cordurié's process of steaming lead.

This contains 6·22 per cent. of oxide of lead. From the Par Smelting Works. Communicated by J. G. Hochstatter.

1526. Another powdery deposit in the chimney, in Cordurié's process of steaming lead.

From the Par Smelting Works. Communicated by J. G. Hochstatter.

PURIFICATION OF HARD LEAD.

1527. Sample of "hard lead."

Contains antimony, arsenic, copper, nickel, cobalt, and possibly other ingredients. It shows a brilliant crystalline surface on one side, with platy and octahedral crystals.

1528. Slag lead from Atkins' Works, Derbyshire.

This is a hard lead, and requires to be softened. It has soft, rounded, radiating fibres.

1529. Crystals from hard lead, from very coarse ore.

They are dull and platy.

1530. Substance obtained in the liquating of hard lead.

At the Dee Bank Lead Works, Bagillt. The upper lamellar portion is a speiss; the lower is in soft small pyritic crystals. Communicated by A. Dick.

1531. Speiss obtained from the lead smelted in a flowing furnace.

Contains much antimony, and probably some cobalt. A layer of regulus is seen on the top.

1532. Result of smelting hard lead, with various residual substances, containing lead, mixed with a poor coppery regulus, to separate copper from the hard lead.

This mass of hard lead, containing silver, when molten, was left to cool slowly. It consists of three parts. The top part contains—

Lead - - - - -	42·22
Iron - - - - -	19·39
Copper - - - -	11·15
Antimony - - - -	4.93
Sulphur - - - -	21·41
	99·10

This is, therefore, a regulus. The middle part is crystalline, granular, and like pig-iron in structure, and of the colour of antimony. The lower, largely crystalline, and foliated part, contains—

Lead - - - - -	57·83
Tin - - - - -	9·40
Copper - - - -	2·44
Iron - - - - -	0·18
Nickel - - - -	0·89
Antimony - - - -	27·55
Arsenic - - - -	0·62
Sulphur - - - -	0·52
	99·43

Analysis by W. J. Ward. *See* Percy's Metallurgy, Lead, p. 467, and Silver and Gold, p. 669.

1533. Results of experiments on liquating hard lead.

(1.) Liquated lead : granulated. (2.) Residual lead, last poured out : dull and soft. (3.) Sulphide after liquation : grey dust with pyritous lumps. (4.) Sulphide that first comes to the surface on melting : broadly crystalline and dull.

1534. Lead liquated from copper, first stage.

1535. Lead liquated from copper, second stage.

LEAD FUMES.

1536. Lead fume from the flue of the smelting furnace.

From the Bagillt Lead Works, 1859. This sample is made from portions of fume taken at different distances out of the main flue, into which the short flues enter, from 10 yards, at intervals of 50 yards. Analysed by W. Weston.

Protoxide of lead - - -	46·54
Sulphide of lead - - -	4·87
Iron oxide and Alumina - -	4·18
Zinc oxide - - - -	1·60
Lime - - - - -	6·07
Sulphuric acid - - -	26·51
Insoluble - - - -	10·21
	99·98

See Percy's Metallurgy, Lead, p. 451. A reddish-white powder.

1537. Lead fume deposited at the bottom of the stack.

From the Bagillt Lead Works, 1859. This consists of the mixed fumes of the smelting furnaces and slag-hearth. Analysed by W. Weston.

Protoxide of lead	62·26
Sulphide of lead	1·05
Iron oxide and Alumina	3·00
Zinc oxide	1·60
Lime	3·77
Sulphuric acid	25·78
Insoluble	1·97
	99·43

See Percy's Metallurgy, Lead, p. 481. A white powder.

1538. Lead fume from the slag-hearth.

From the Bagillt Lead Works, 1859. Taken from the slag-hearth flue before its junction with the main flue. Analysed by W. Weston.

Protoxide of lead	46·88
Iron oxide and Alumina	10·00
Zinc oxide	4·14
Lime	6·73
Sulphuric acid	14·15
Insoluble	14·40
Carbonaceous matter from fuel	3·37
	99·67

See Percy's Metallurgy, Lead, p. 451. A grey powder.

1539. Lead fume as taken from the condenser.

From the Keld Head Lead Works, Wensleydale, Yorkshire. A dark grey aggregated powder.

1540. Series of lead fumes from different parts of the same condensing system.

Probably from the Keld Head Lead Works, Yorkshire. Nos. 1, 2, 3, 4 position not stated. No. 5 from above the little condenser. No. 6 from the top of the chimney. No. 7 from the cistern. No. 8 position not stated. They are light coloured powders of various shades, the darkest being No. 6.

1541. Four samples of lead fumes from the Alport Lead Works, Derbyshire.

No. 1 is from the first condensing chamber in connexion with the slag-hearth, and is an aggregated grey dust. Nos. 2–4 are from the return flue, after passing through the condenser. No. 2 is lighter grey. No. 3 nearly white. No. 4 light brown.

1542. Another series of lead fumes from the Alport Lead Works, Derbyshire.

Locality in flue not stated. They are labelled Nos. 2, 3, 4. No. 2 is the darkest; the others are light brown, or nearly white.

1543. Fume from the cupelling hearth.
From a German lead works. It is called "Frisch Raust," and is a hite powder.

ILLUSTRATIONS OF SMELTING COMPLEX ORES, CONTAINING LEAD AND OTHER METALS, AS CARRIED ON IN THE HARZ.

PRIMARY OPERATIONS.

1544. Compact galena. The lead ore on which the operations are made.

1545. Once-roasted lead ore, "1-mal geröstetes Bleierz."
It is now brown and lighter.

1546. Twice-roasted lead ore, "2-mal geröstetes Bleierz."
A dark brown earthy mass.

1547. Thrice-roasted lead ore, "3-mal geröstetes Bleierz."
In small brown earthy fragments.

In the preliminary process of roasting the ore, sulphur is given off, which is recovered as below—

1548. Raw sulphur from the roasting, "Rohschwefel."
Cast into a thin cake. The thrice-roasted ore is smelted with zinc slag.

1549. Calamine or silicate of zinc from whence the zinc is obtained, "Galmei."
An impregnated slate.

1550. Zinc reduced in the process.
Covered with a coat of slag.

1551. Slag, "Schlacke."
A hard regulus-like mass, with large cavities.

The products obtained are—

1552. Blast-furnace lead, "Werkblei."
The basis of the refining operations. For analysis, *see* Percy's Metallurgy, Lead, p. 312.

1553. Furnace accretion, "Ofenbruch."
Consisting of a mass of minutely crystallised stalactitic impure lead.

1554. Marl-bottom of the furnace, "Lehmsohle."
This becomes impregnated with the litharge, and also more or less melted.

1555. Lead regulus, "Bleistein."
This contains a portion of the lead which has afterwards to be worked. It is a massive slabby substance, and contains the impurities including copper. For analysis, *see* Percy's Metallurgy, Lead, p. 313.

The next operations are performed upon the blast-furnace lead (No. **1552**), refining it by means of cupellation, yielding the following products—

1556. Scum, "Abzug."

This is the rubbish which forms on the surface of the lead when molten, and consists of a mixture of dark earthy fragments, containing oxide of lead with the impurities which may be present.

1557. Skimming poor in lead, "Bleiarmer Abstrich."

A stony decaying mass, consisting mostly of litharge, being formed after the removal of the Abzug; it is sometimes called "black litharge." *See* Percy's Metallurgy, Lead, pp. 194, 201.

1558. Skimming rich in lead, "Bleireicher Abstrich."

An earthy-looking mass, consisting of a purer mixture of litharge with other materials, taken off at a later stage of the cupellation.

1559. Litharge for reduction, "Frisch-Glätte."

This is the last product to be driven off and collected in a molten form. It is now white, earthy, and crumbling.

1560. Brightened silver, "Blicksilber."

This is the mass that is left after the lead has been oxidised and driven off. When the mass loses the last trace of litharge it suddenly brightens, and is then Blicksilber. This contains numerous large rounded cavities below the surface, formed by the gas which did not escape, and which raises the surface into hills. The whole mass is composed of finely arborescent silver crystals. The upper surface has a thin layer of yellow vitreous oxide of lead. It has been analysed by R. Smith, and contains 96·95 per cent. of silver. *See* Percy's Metallurgy, Lead, p. 196.

1561. Marketable litharge, "Kauf-Glätte."

Consisting of red and white scales of tolerable purity.

1562. Furnace bottom, "Heerd."

Marl strongly impregnated with litharge. *See* Percy's Metallurgy, Lead, p. 203.

The working up of the Scum, "Abzug."

On smelting this the following three substances are produced—

1563. Lead for operations, "Werkblei."

A sample of the impure lead.

1564. Regulus from the scum, "Abzugstein."

A porous irregular stony mass, containing much metal.

1565. Slag, "Schlacke."

A blue glassy mass, with large holes.

The lead thus obtained is now liquated, and produces—

1566. The more purified lead for operations, "Abzugswerkblei."

A sample from the lead liquated from the copper and other impurities, except silver.

1567. Liquation rubbish from the scum, "Abzugsaigerkratz."

A mass of mixed materials including charcoal.

The first of these products is now cupelled as the first lead was, and yields—

1568. The scum, "Abzug."

This includes all the rubbish that collects on the surface of the molten lead, in separate small pieces.

1569. First skimming, "Abstrich."

A dark impure litharge material.

1570. Second skimming, "Abstrich."

A solid mass of greenish impure litharge.

1571. Litharge, "Glätte."

Flowing off at a later stage as a micaceous mass.

1572. The residual Blicksilber from this process, to obtain which is its object.

A swollen doubly convex mass, with a cavity inside and a tail-like process.

1573. Furnace button, "Heerd."

Marl, richly impregnated with litharge, and which will be worked up again with it when the litharge is reduced.

The liquation rubbish is also smelted, and produces a mass of workable lead, some slag, and—

1574. Regulus from the liquation rubbish, "Abzugsaigerkratzstein."

A porous crumbling mass, which contains all the copper.

On smelting and treating this in a suitable manner, there are obtained—

1575. Refinery slag, "Verblasenschlacke."

A reddish stony mass, which forms the bulk ; and—

1576. The refined copper, "Gaarkupfer."

In the form of a long hollow finger.

1577. Roasted lead regulus, "Geröstete Bleistein."

This is the result of the first operation. It is then smelted, and yields three products. A dark loose cinder.

1578. Poor lead from liquating, " Armwerke.

This consists of the lead which has been liquated off, and which contains all the silver there was in the copper, but this does not amount to very much.

The treatment of the Lead Regulus.

1579. Slag, " Schlacke."

A blue-tinted compact regulus-like mass, with large flat holes and a blistered surface.

1580. Furnace regulus, " Rohstein."

A crystalline ½-inch slab, the subject of future operations.

1581. Black copper, " Schwarzkupfer."

This is dark and granular in fracture, and requires much refining, but the operation is not connected with lead.

The furnace regulus is again roasted, forming roasted regulus, " Rohrost," not in the collection, and afterwards smelted, producing—

1582. Dark regulus from the roasted regulus, " Rohroststein."

A thin sub-metallic blistery substance which is again operated on, yielding a second crop of copper.

1583. Black copper, " Schwarzkupfer."

Of arborescent crystalline form, to be still further treated for obtaining copper.

1584. Slag, " Schlacke."

A light sub-metallic-looking thin sheet with large holes. The black copper when refined yields granulated copper, " Granalien," and refinery slag, " Verblasenschlacke," but these are not in the collection.

The dark regulus is again roasted, and yields—

1585. Roasted regulus, " Geröstete Rohroststein " or " Kupferrost."

An irregular cinder-like dark mass. This is afterwards smelted, and yields a third crop of copper.

1586. Black copper, " Schwarzkupfer."

A porous mass, forming the final product so far as the lead processes are concerned.

1587. Thin matt, " Stein."

A very thin metallic-looking covering with vertical holes, used again in combination with other products.

1588. Slag, " Schlacke."

A hard, solid, metallic-looking crust, also worked up again.

1589. Lead regulus, "Bleistein."

A porous earthy mass. The result of smelting the ores in the blast furnace, Freiberg.

1590. Roasted lead regulus, "Geröstete Bleistein."

A cindery brown mass ; the first result of the second operation.

1591. Lead slag, "Bleischlacke."

A compact dark mass with large holes, glassy below, and with flow lines and fragments above.

1592. Regulus slag, "Bleisteinschlacke."

The slag produced in the first operation, a rough mass full of holes, and with fragments of unsmelted ore.

1593. Litharge refinery slag, "Glattfrischeschlacke.'

The slag produced in the later refining process ; a very scoriaceous dark mass.

LEAD WORKING AT MULDNER HÜTTE, &C., FREIBERG.

The series from Freiberg (so labelled) is very incomplete.

1594. Lead regulus, "Bleistein," from Halsbruckner Hütte.

This is the result of previous operations on mixed ores containing both copper and lead. A 1½-inch compact slab with cavities.

1595. Lead regulus, "Bleistein," and speiss from Muldner Hütte.

This is a porous, dark, heavy mass with mixed metallic contents, and having a thin coating of speiss containing arsenic and antimony.

1596. Lead speiss, Muldner Hütte.

The antimonious lead regulus obtained in smelting. It is a 1½-inch metallic, broadly crystalline slab.

1597. The lead obtained from the lead regulus, "Bleisteinwerke."

This has to be afterwards subjected to refining processes, and is, therefore, called "Werke."

1598. Speiss from Bleistein smelting, Muldner Hütte.

Another more massive example of the antimonious regulus, with irregular crystals of a golden colour.

1599. Lead slag, "Bleischlacke."

From the lead workings at Muldner Hütte, but the stage is not stated. It is apparently in part metalliferous. A solid, black, submetallic slate.

1600. Lead obtained from the smelting of coarsely powdered galena, "Schliegwerkblei."

The ore is first ground to coarse powder called "Schlieg," before being smelted : this is the first product of the reduction by iron, it has afterwards to be refined. *See* Percy's Metallurgy, Lead, p. 369.

1601. The first skimmings of the already scorified molten lead, "Abstrich."

This is the first coating of impurities after the scum, or "Abzug," in the cupellation furnace. Consists of a mixture of litharge and other materials in compact masses.

1602. The second skimmings of the molten lead, "Abstrich."

The litharge in this is a more abundant ingredient, and it is more crystalline and regular, forming a thin slab.

1603. Litharge ready for reduction, "Frisch-Glätte."

A yellow, micaceous, crumbling mass, consisting of the pure litharge after the "Abstrich" has been drawn off. At a later stage, and by a separate process, it will be reduced again to lead.

1604. Litharge crystals formed under particular circumstances at this stage.

A set of loose white flakes.

1605. Lead reduced from the skimmings and requiring to be refined, "Abstrich-Frisch-Blei."

1606. Lead derived from the skimmings which contains gold, and which will be treated for its extraction, "Goldgekratz-arbeit."

1607. Gneiss impregnated with minium from the base of an old furnace at Freiberg.

Communicated by H. Bauerman.

1608. Furnace product from Freiberg.

It consists of arborescent interlacing crystallisations of a dark colour, interspersed with brilliant rhombic prisms. It has not been analysed. Communicated by Mr. Bell.

1609. Crystallised slag from the lead furnaces at Freiberg.

It is massive below, but shows a remarkable foliation in its substance; on the surface are irregularly placed flat plate-like crystals, often arranged in a hopper-shaped manner. Communicated by Mr. Bell.

1610. Artificially crystallised product from the Muldner Hütte, Freiberg.

This has a long columnar fracture and platy crystallisation, and an iridescent surface; it doubtless contains antimony.

MISCELLANEOUS FOREIGN LEAD SMELTING.

1611. "Slagged ore" from the lead works at Mechernich, Rhenish Prussia.

The materials used in these works are "potters' ore," "white lead ore," and common ore, and the mixture is first calcined at the cooler part of the furnace; by this means the lead is oxidised, and when melted with the siliceous ingredients accompanying it in the hotter part, forms a silicate of lead which is called slagged ore. A black-spotted glass which has afterwards to be reduced. *See* Percy's Metallurgy, Lead, p. 352.

1612. Crystalline purple slag.

A pink, crystalline, transparent coating, possibly from the Mechernich Lead Works.

1613. Crystallised product, from the slag heaps at Mechernich.

The slagged ore is afterwards smelted in a blast furnace with half its weight of puddling-furnace slags, and half of limestone; lead and lead regulus is obtained; the slag left is mostly a silicate of iron in long, black, thin prisms, and is thrown away. Communicated by W. Frecheville, 1874.

1614. Banded slag, from the blast furnace at Mechernich.

This has been obtained from the side of the furnace, and shows stages of crystallisation; the inner band is composed of flat, triangular, arborescent crystals, intersecting at right angles in a point, forming sharp prismatic ends. Communicated by W. Frecheville, 1874.

1615. Stalactitic galena which has been melted in the bed of a reverberatory furnace.

From the works of the Rheinisch-Nassau'sche Actien-Gesellschaft. It shows a large, brilliant, prismatic fracture. Communicated by W. Frecheville, 1874.

1616. Part of sow (Anglice, " Bear "), from lead smelting in the Rachette Furnace.

An earthy slag, with fragments of charcoal. Clausthal Silver Hütte, 1873.

1617. Lead ore for roasting in the small calciner.

It contains 12 lbs. 7 ozs. 5 dwts. 8 grains of silver per ton. From the Halsbruckner Hütte.

1618. Roasted ore from small calciner at Halsbruckner Hütte.

The charge was 6 cwt., and it was roasted five hours. It consists of hard black fragments and dust.

1619. Ancient lead slags, from Laurium, Greece.

Two brown, earthy-looking masses. Communicated by H. G. Bell.

1620. Impure lead, obtained by fusing the ancient Greek scoria and ekvolades.

From the Laurium Smelting Works, Greece. Communicated by H. G. Bell.

1621. Ancient lead slag, now being resmelted at Laurium, Greece.

It is heavy and dark, like a modern roasted ore. Communicated by H. G. Bell.

1622. Ancient litharge found at Laurium, Greece.

A very heavy mass, probably containing metallic lead in the centre. Communicated by H. G. Bell.

1623. Lead fume, from Laurium, Greece.

These masses are in part irregular; but in some places are in the form of branched columns, which are blue within, but have a white exterior. Each column is banded across by darker and lighter bands, which go across at the same level from one column to another, and they are sometimes broken off at these levels. Thus they have all grown at the same time, and it is probable that when formed the columns were all joined, and that they have separated at a later stage as the fume cooled. Communicated by H. G. Bell.

1624. Litharge from the lead-refining works at Utah, U.S.A., 1875.

Communicated by H. Blackwell.

Samples of Metallic Lead.

1625. Square ingot of lead, showing crystals on the surface.

These crystals radiate in long bands from the sides and corners, with branches and secondary branches, placed obliquely. Ingot marked J. M.

1626. Arborescent crystals of lead, built up into skeleton octahedra.

From the Elswick Lead Works, Newcastle-on-Tyne. Obtained by lifting a large block of lead before it was quite set in the mould. Communicated by E. A. Walker.

1627. Crystallised lead, obtained experimentally.

Molten lead is poured into an iron ingot mould, and when set the surface is broken and the ingot inverted, leaving the unsolidified lead to flow out.

1628. Crystallised lead, obtained in Pattinson's process.

A sheet with its surface covered by fine tetrahedral points with arborescent sides. Communicated by H. L. Pattinson, 1849.

1629. Crystallised lead in a prismatic form.

A cavity in a solid cylinder 4 in. in diameter and 5 in. in length, cast in an ordinary sand mould, showing the crystals. Communicated by H. H. Smith.

1630. Specimens showing dependence of the fracture of lead on its purity.

One pair of pieces are unrefined lead, the other pair showing a columnar fracture have been purified by two re-crystallisations. Communicated by Mr. Baker, of Sheffield.

1631. Pig lead, broken to show fracture.

This is practically pure lead, made by Mr. Baker, of Sheffield, and shows columnar fracture.

1632. Lead showing columnar structure.

They are starch-like columns, starting from the sides of a bar and meeting toward the middle.

1633. Granulated lead, obtained by pouring molten lead into water.

1634. Finely granulated lead, in powder.

1635. Sample of the purest possible lead.

It was made by repeatedly scorifying 100 tons of the purest lead in the Dee Bank Lead Works, Holywell, until it was reduced to 5 tons. Suitable for special experiments on pure lead. Prepared by A. Dick.

1636. Lead cylinder, out of which bullets are made.

The fracture is seen to be concentric. This is due to the flowing of the metal at different rates as it cools from the sides.

1637. Lead without antimony.

Extraordinarily refined by repeated crystallisation and long melting, whereby the antimony is all oxidized and the lead left whiter. It shows a coarse columnar fracture, of a pure grey tint.

1638. Lead with a trace of antimony.

To compare with No. **1637.** It shows a finer columnar structure, and has a purplish tint characteristic of the presence of antimony, even when present to the amount of not more than 0·01 per cent.

1639. Artificial slag lead.

Produced by adding 0·25 per cent. of antimony to refined lead. The colour is rendered remarkably white on the fracture, and resembles that of ordinary slag lead. The surface of the columns is spotted.

1640. Antimonial lead.

Communicated by Mr. Keates, of Bagillt Lead Works, Holywell. Analysed by W. J. Ward.

Lead - - - - -	87·58
Antimony - - - -	10·38
Copper - - - -	1·52
Iron - - - - -	0·20
Silver - - - -	0·01
	99·69

The fracture is very irregular, and the antimony is probably not in combination with the lead, but merely mixed as a separable impurity.

1641. Lead free from arsenic poured from a height of about 8 feet on to a sheet of paper on the floor.

The lead is in very irregular fragments of all sizes, only some of which are round.

1642. Lead containing arsenic poured from a height of about 8 feet on to a sheet of paper on the floor.

The lead is all in round shots, only differing in size. These two samples are the results of experiments in a lecture to working men in 1885 on the influence of arsenic on the properties of lead.

1643. Lead shot analysed for arsenic. No. 1 shot.

This contains 0·133 per cent. of arsenic and 0·030 per cent. of copper. Analysis by R Smith. *See* Percy's Metallurgy, Lead, p. 72.

1644. Lead shot analysed for arsenic. No. 6 shot.

This contains 0·1157 per cent. of arsenic and 0·284 per cent. of copper. Analysis by R. Smith. *See* Percy, l.c.

1645. Five samples of lead contaminated with copper.

That labelled 3 L contains 0·147 per cent. of copper, 11 L contains 0·375 of copper, 12 L contains 0·445 of copper, 13 L contains 0·368 of copper, and 14 L contains the same. From the Snailbeach Mines, Shropshire.

1646. Boat-shaped ingot of refined lead from Snailbeach Mines, Shropshire.

1647. Pig of Stanhope lead. Tyne Dock, 1862.

1648. Snailbeach lead, showing peculiar platy fracture.

From Atkins' Works, 1850.

1649. Pig of Greek lead, marked ΕΛΛΑΣ.

1650. Half a disc of Chinese lead.

Brought from Szechuen Province by H. S. Parkes.

1651. Piece of ancient Roman lead from an open working near Carthagena.

Coated over with a crust of litharge by oxidation in the atmosphere. Communicated by H. Bauerman.

1652. Piece of antique lead entirely coated with oxide.

1653. Soft lead from No. 1 best ore. Keld Head Mines, Leyburn.

1654. Slag lead from grey slag. Keld Head Mines.

1655. Lead from melting poor slimes. Keld Head Mines.

1656. Lead from smelting waste ore. Keld Head Mines.

1657. Lead from fume-smelting in double-bedded reverberatory furnace. Keld Head Mines, Leyburn.

The above five specimens are small ingots, differing little in appearance. Communicated by W. Weston.

1658. Lead from reverberatory furnace.

From the Alport Lead Works, Derbyshire.

1659. Unsoftened lead from the slag-hearth.

From the Alport Lead Works, Derbyshire.

1660. Lead from the Spanish slag-hearth.

From the Bagillt Lead Works, Holywell.

1661. Lead from the Flintshire Furnace.

From the Bagillt Lead Works, Holywell, Flintshire.

1662. Lead from silver-ore mixture, in irregular droppings.

1663. Lead from South Australian ore, in irregular droppings

DEFECTS AND CORROSIONS OF LEAD.

1664. Lead pipe imbedded for 30 years in the concrete of the Carnivora House in the Zoological Gardens, Regent's Park, 1870.

It is thickly coated externally with compact amorphous matter in successive layers, which is yellowish near the surface, and internally bluish or greenish grey. Probably acted on by the animals' urine. Analysed by J. W. Ward.

Protoxide of lead - - -	89·80
Peroxide of tin - - -	1·28
Water - - - - -	5·36
Carbonic acid - - - -	0·96
Nitric and nitrous acid - -	2·60
	100·00

See Percy's Metallurgy, Lead, p. 535.

1665. Lead pipe from the Houses of Parliament corroded from the outside.

1666. Lead pipe corroded on the outside to lead oxide.

This is part of a pipe for the conveyance of cold water at the Houses of Parliament. It was imbedded for several years in Portland cement and was taken out in 1877. Analysed by W. J. Ward.

Lead oxide - - - -	98·84
Carbonic acid - - - -	0·70
Water - - - - -	0·73
	100·27

It is a solid red mass without structure, and the remains of the lead pipe within is very thin. Communicated by Mr. Jones, Clerk of the Works.

1667. The Portland cement in which the corroded lead pipe was laid.

1668. Piece of disintegrated lead.

This is from the lead cistern of a railway truck, constructed to carry vitriol in bulk. It has become transversely brittle.

1669. Piece of old lead pipe showing longitudinal cracks.

Contains 0·0072 per cent. of silver.

1670. Piece of corroded sheet lead.

Taken from the flange joint of blow-off pipe under No. 10 old boiler, Houses of Parliament. It is very irregularly eaten away.

1671. Sheet lead corroded into numerous holes.

This lead was used for lining wooden troughs for soaking cotton in before 1840 in the Cotton Spinning Works of Arkwright and Melville, Matlock Bath. The water used was derived from the millstone grit, and no perforations were observed in another mill where the water was derived from the carboniferous limestone, but the lead was the same. The holes and pits are on the side next the water, and not next the wood. They are from $\frac{1}{8}$ in. to $\frac{1}{16}$ in. in diameter; some are very regular, but others are irregular. It has been suggested that they may be due to insects. *See* Percy's Metallurgy, Lead, p. 522. Communicated by Mr. Melville, 1840.

1672. Corrosions of lead into white lead, showing the dependence of the colour on the quality of the lead.

The four samples show different amounts of silver per ton on analysis. No. 1 has 6 dwts. 12 gr.; No. 2, 13 dwts. 1 gr.; No. 3, 19 dwts. 14 gr.; No. 4, 1 oz. 2 dwts. 5 gr.; and the gradual appearance of a pink tint, due to the presence of the silver, may be detected. Communicated by W. Baker, Sheffield.

1673. Corrosion of pure lead with a certain amount of sulphur.

1674. Corrosion of lead containing ·0071 per cent. of copper and ·0029 per cent. of iron.

1675. Corrosion of lead containing a trace of copper, ·0056 per cent. of iron, and 1 oz. 16 dwts. 14 gr. of silver to the ton.

1676. Corrosion of refined slag lead, containing ·0007 per cent. of copper and ·0061 per cent. of iron.

1677. Corrosion of lead, containing ·0088 per cent. of copper and ·009 per cent. of iron.

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1678. Corrosion of lead, containing ·0931 per cent. of copper, ·0092 per cent. of iron, ·0376 per cent. of antimony, and ·0516 per cent. of sulphur.

These six, Nos. **1673** to **1678**, are small white experimental slabs.

1679. Piece of sheet lead which is broken up into small subdivisions, where corroded into oxide on one side; all these are held together by the uncorroded portion on the other side.

No history is attached to this specimen; possibly it is a portion of the lead lining of the cisterns conveying sulphuric acid. *See* No. **1668.** Communicated by Mr. A. Walker.

ALLOYS OF LEAD.

1680. Alloy of sixteen and a half parts of lead to four of tin.

Fuses at 500° Fahr.

1681. Alloy of three parts of lead to one of tin.

1682. Alloy of eight and a half parts of lead to four of tin.

Fuses at 450° Fahr.

1683. Alloy of two parts of lead to one of tin, called multiplying metal.

1684. Alloy of three and a half parts of lead to four of tin.

Fuses at 400° Fahr.

1685. Alloy of one part of lead to three of tin, called multiplying metal.

1686. Alloy of two parts of lead to one of bismuth.

It has been hammered out to show its malleability. It broke across on twice bending it in a vice.

1687. Alloy of 66 parts of lead to 34 of bismuth.

1688. Alloy of lead containing 20·73 per cent. of arsenic.

1,000 grains of granulated lead were melted with an equal amount of arsenic. A fusible alloy was formed, which is very brittle and has a crystalline fracture, and soon tarnishes to a black colour. The composition by weight is said to correspond to an arsenide of lead (Pb_3As), but this is not the case with the modern numbers. Experiment by J. C. Cloud. *See* Percy's Metallurgy, Lead, p. 72.

1689. Alloy of lead containing 38·55 per cent. of arsenic.

1,000 grains of lead were kept melted under charcoal, while 2,000 grains of metallic arsenic were gradually added and stirred in. The temperature was then raised to produce perfect fusion. The ingot weighed 1,600 grains. It is brittle, has a crystalline fracture, and soon tarnishes. The composition by weight is said to correspond to an arsenide of lead ($Pb\ As$), but this is not the case with the modern numbers. Experiment by J. C. Cloud. *See* Percy's Metallurgy, Lead, p. 72.

1690. Alloy of one part of lead to one of antimony.

Shows a coarsely crystalline fracture.

1691. Alloy containing two equivalents of lead to one of antimony, or 76·2 per cent. lead and 23·8 per cent. antimony.

Shows a granular fracture.

1692. Alloy of lead containing five per cent. of aluminium.

Remains quite malleable, but has a whiter tint.

1693. Attempt at forming an alloy of lead and iron.

88 parts of lead were melted with 12 parts of iron, or in the proportion of two equivalents of lead to one of iron, and the mixture allowed to cool. No combination took place, and there is still lead at the bottom and iron at the top.

1694. Alloy of eight parts of lead, two of antimony, and one and a half of tin.

Forms stereotype metal.

1695. Alloy of three parts of lead, five of bismuth, and two of tin.

Forms the alloy used for stereotype clichés. The pieces are flattened out and impressed.

1696. Alloy of four parts of lead, one of bismuth, and three of tin.

This melts at 352° Fahr.

1697. Alloy of two parts of lead, six of bismuth, and one of tin.

This melts at 300° Fahr.

1698. Alloy of equal parts of lead, bismuth, and tin.

This melts at 254° Fahr.

1699. Alloy of five parts of lead with eight of bismuth and three of tin.

This is known as fusible metal, and melts at 202° Fahr.

1700. Alloy of one part of lead with two of bismuth and one of tin.

This melts at 200° Fahr.

VARIOUS USES OF LEAD AND ITS ALLOYS.

1701. Spongy lead, suitable for electrical accumulators.

Williams and Howell's patent 2573, 1883. This lead is produced by dipping a perforated ladle into a mixture of lead and crystallised lead, and raising it out of the pot and letting the more liquid lead drain out of the bottom; the lead which is left in the ladle will be porous. Of the two samples here shown one has had its surface smoothed, and the other has had the outer skin removed to show the internal structure. They are both cut out of a thick block by circular saw. Communicated by Mr. Williams, of Nevill, Druce, and Co.'s Lead Works, Llanelly.

1702. Jacobæan medal, made of lead.

Probably of the 17th century. Represents the King with a shield of "passive obedience," against two men, one with a dagger and the word "Burces," and the other going away with the word "separation."

1703. Leaden comb, used for making the hair black.

1704. Lead pipe coated internally with tin.

A piece of tin is put into the mould through which the heated viscous lead is forced. From the International Exhibition, 1862.

1705. Piece of an old Egyptian lead coffin.

It has become transversely columnar. It contains 2 oz. 4 dwts. 10 grains of silver per ton, and a trace of gold. Communicated by the Royal Artillery Institution, Woolwich.

1706. Nail made of a patented alloy, used for fastening slates to roofs.

Partially analysed by C. Tookey. They contain 77·9 per cent. of lead and 21·1 per cent. of antimony, and a small quantity of zinc.

1707. Various counterfeit British coins.

Composed of various alloys of lead, &c.

1708. Terra de Siena.

A yellow-coloured glass composed of silicate of lead, cut into ornaments as an artificial gem.

TYPE METALS.

1709. Higgins' small pica type metal.

1710. Wilson's small pica type metal.

1711. Fry's pica type metal.

1712. Caslon's English type metal.

These four are broken to show their granular fracture.

1713. Bolitho's Bombay type metal.

1714. Type cast in patent hard metal.

1715. Large ingot of Higgins' small pica.

1716. Large ingot of Wilson's small pica.

1717. Large ingot of Caslon's English.

1718. Large ingot of Fry's pica.

1719. Series of experimental combinations of lead, tin, and antimony.

Made by C. Tookey with a view to finding the most suitable proportions for type metals. About 15,300 grains in each case were taken in all. The lead and tin were melted together first, and the antimony was then added. Stick charcoal was used to form a covering, and then resin was added. The whole was stirred up and poured after clearing back the impurities.

A. contains no lead, tin 75, antimony 25 per cent.
B. contains lead 10, tin 65, antimony 25 per cent.
C. contains lead 75, no tin, antimony 25 per cent.
D. contains lead 75, tin 5, antimony 25 per cent.
E. contains lead 20, tin 55, antimony 25 per cent.
F. contains lead 30, tin 45, antimony 25 per cent.
G. contains lead 65, tin 10, antimony 25 per cent.
H. contains lead 60, tin 15, antimony 25 per cent.
I. contains lead 40, tin 35, antimony 25 per cent.
J. contains lead 50, tin 25, antimony 25 per cent.
K. contains lead 55, tin 20, antimony 25 per cent.
L. contains lead 45, tin 25, antimony 30 per cent.
M. contains lead 50, tin 20, antimony 30 per cent.
N. contains lead 70, no tin, antimony 30 per cent.
O. contains lead 65, tin 5, antimony 30 per cent.
P. contains lead 55, tin 15, antimony 30 per cent.
Q. contains lead 60, tin 10, antimony 30 per cent.
R. contains lead 40, tin 25, antimony 35 per cent.
S. contains lead 45, tin 20, antimony 35 per cent.
T. contains lead 65, no tin, antimony 35 per cent.
U. contains lead 60, tin 5, antimony 35 per cent.
V. contains lead 50, tin 15, antimony 35 per cent.
W. contains lead 55, tin 10, antimony 35 per cent.

These vary very considerably in fracture, the most crystalline being W., the finest D.

1720. Didot's metal.

Made by C. Tookey, 1861. Contains lead 30, tin 30, antimony 30, and copper 10 per cent. It has a very irregular and platy fracture.

1721. Series of type castings. Made by combination of the above.

A. on C., C. on C., J. on C., C. on J., J. on D., A. on Didot, Didot on A.

1722. Type made from the alloy containing 50 per cent. of lead, and 25 per cent. each of tin and antimony.

1723. Long primer type, No. 11, made in 1846.

1724. Brevier type, No. 12, made in 1841.

1725. Pearl type metal. Made in 1850.

1726. Two samples of type cast at a high temperature from Didot's metal; the larger type cast at a slightly higher temperature.

SILVER.

EXPERIMENTS.

1727. Result of heating oxide of silver with charcoal.

This shows the reducing power of charcoal. The reaction takes place at different temperatures below 300° C., according to the proportions. The silver is produced in a powdery form. *See* Percy's Metallurgy, 1861, p. 17; and Silver and Gold, p. 10.

1728. Silver button from cupellation swollen by included oxygen.

The silver was reduced from the chloride by heating to fusion with carbonate of soda. The silver thus obtained was cupelled with an equal weight of lead, and left to cool for some time in the muffle. This button of silver was obtained, the "spitting" having occurred over the whole surface of the metal, and a subsequent rising in the weakest portion of the crust. It has been cut off to show that the upper convex surface is not due to any accidental shape of the solid silver, but to a rising produced by the oxygen given off during solidification. Experiment by R. Smith, March 1888.

1729. Repetition of Plattner's experiment on the action of oxygen on finely divided silver at a red heat.

Three grammes of finely divided silver were carefully mixed with an equal bulk of finely triturated quartz. The mixture was inserted in a glass tube half an inch diameter and two feet long, and the part where the mixture was, was coated with platinum foil to distribute the heat. A current of dry oxygen was passed along the tube for an hour, while the mixture was kept of a moderate red heat by an argand burner. At this temperature the silver has been said to be oxidised and rendered volatile, and then reduced again in the cooler part of the tube, where a metallic mirror has been said to be formed. No such metallic mirror has been produced in this case by Dick and Tookey. *See* Percy's Metallurgy, Silver and Gold, p. 19.

1730. Sulphide of silver in the condition of a powder.

Prepared by passing hydro-sulphuric acid through a solution of chloride of silver in ammonia.

1731. Pure sulphide of silver in powder dried at a high temperature.

1732. Sulphide of silver in a solid radially crystalline form.

Produced by fusing together silver and sulphur.

1733. Result of fusing together silver and sulphide of silver. (Experiment I.)

A mixture of 648 grains of silver and 248 grains of sulphide of silver was melted under charcoal in a clay crucible and there left to cool. The result weighed the same as the mixture, and consists of a layer of sulphide of silver at the top uncombined, weighing 119 grains, and a compound at the bottom weighing 777 grains. It therefore represents a compound of twelve equivalents of silver with one of silver sulphide. Experiment by R. Smith. *See* Percy's Metallurgy, Silver and Gold, p. 25.

1734. Result of fusing together silver and silver sulphide. (Experiment II.)

260 grains of silver were melted with 100 grains of sulphide. The product was similar to that of Experiment I. The lower layer being analysed gave, silver 83·63 per cent., sulphide of silver 16·37 per cent. Experiment by Edgar Jackson. *See* Percy's Metallurgy, l.c.

1735. Result of fusing together silver and silver sulphide. (Experiment III.)

Silver and its sulphide were fused together in the proportions of the lower layer as analysed in Experiment II., and a homogeneous metallic product is thus obtained, showing that the two combine in definite and no other proportions. *See* Percy's Metallurgy, l.c.

1736. Sulphide of silver produced by fusion not entirely protected from air.

This has been melted in a covered crucible and left to cool therein. There are numerous barnacle-like protuberances of metallic silver on the surface, produced by the imperfect protection of the fused sulphide from the air, by which it has been partially reduced. Experiment by R. Smith. *See* Percy's Metallurgy, Silver and Gold, p. 27.

1737. Silver precipitated in an arborescent form by means of iron.

A microscopic slide. Communicated by Mr. Makin, 1872.

1738. Silver reduced from its chloride by zinc in the cold.

In the form of a grey powder.

1739. Silver reduced from sulphide of silver by hydrogen.

When heated in a current of hydrogen sulphide of silver is reduced in a capillary form. *See* Percy's Metallurgy, Silver and Gold, p. 28.

1740. Silver reduced from sulphide of silver by hydrogen.

In a glistening powder. Sealed in 1869.

1741. Metallic silver produced in burning a filter containing some sulphate of silver.

1742. Result of heating together two equivalents of silver oxide with one of silver sulphide.

62 grains of the sulphide were heated with 116 grains of oxide of silver in a crucible to the melting point of silver. Metallic silver separated and was poured out. It weighed 156 grains. Its fracture is bluish grey, partly granular and partly fibrous, and it contains some sulphide of silver, while the total original weight of silver was 162 grains. This shows the mutual reduction of these two silver compounds. Experiment by R. Smith. *See* Percy's Metallurgy, Silver and Gold, p. 37.

1743. Result of heating together one equivalent of sulphide of silver with two of oxide of lead.

The mixture fused with effervescence, and the metallic alloy produced contains sensibly all the silver and lead in the mixture employed. Experiment by R. Smith. *See* Percy's Metallurgy, Silver and Gold, p. 38.

1744. Result of heating together one equivalent of sulphide of silver with four of oxide of lead.

62 grains of sulphide of silver were heated with 223 grains of oxide of lead. The same metallic alloy was produced with a fine-grained bluish-grey fracture. It weighed 152·5 grains, out of 157·5 grains of silver and lead in the original mixture, and there could not therefore be any sensible formation of sulphate of lead. Experiment by R. Smith. *See* Percy's Metallurgy, l.c.

1745. Result of heating together sulphides of lead and silver.

It is a blue-black powder.

1746. Sulphide of silver which has been cupelled, giving a per-centage of silver from 84·79 to 84·702.

1747. Result of heating together one equivalent of sulphide of silver with one of sulphate of silver.

62 grains of the sulphide were heated in a clay crucible with 78 grains of the sulphate of silver. The mixture fused with effervescence due to sulphurous acid, and produced a metallic button of very white colour and of finely fibrous fracture, weighing 107·9 grains, out of 108 grains in the original mixture. Practically therefore the whole of the silver is reduced. Experiment by R. Smith. *See* Percy's Metallurgy, Silver and Gold, p. 39.

1748. Silver precipitated by sulphite of soda.

When solutions of salts of silver are boiled with an excess of alkaline sulphite silver is precipitated in the form of white powder. Experiment by Edgar Jackson. *See* Percy's Metallurgy, Silver and Gold, p. 48.

1749. Coating of silver spontaneously deposited from Mr. Woolrich's solution of silver in sulphite of potash.

Sulphite of potash is added to an aqueous solution of nitrate of silver, and the precipitated sulphite of silver is redissolved in excess of the precipitant. From this solution under the action of an electric current silver is deposited on the surface of glass or earthenware, as well as upon metallic surfaces, but not upon wood, and it is independent of the action of light. It was this discovery of Mr. Woolrich's, from whom this bottle with the silver coating inside was received in 1845, that laid the foundation of successful electro-plating. *See* Percy's Metallurgy, Silver and Gold, p. 48.

1750. Result of heating sulphide of silver with sulphate of soda.

62 grains of sulphide of silver have been heated with 71 grains of sulphate of soda and kept heated in a clay crucible at a full red heat for about a quarter of an hour with exclusion of air. A button of sulphide of silver, weighing 61·92 grains, is produced at the bottom of the crucible, showing that no action takes place. Experiment by H. Louis, 1876. *See* Percy's Metallurgy, Silver and Gold, p. 39.

1751. Result of heating sulphide of silver with nitrate of potash.

62 grains of sulphide of silver were heated with 186 grains of nitrate of potash in a clay crucible. Fusion with effervescence occurred at a low red heat. The result was a slag-like mass, and a button of silver weighing 52·5 grains. It is white, vesicular and uneven on the surface, by the absorption and evolution of oxygen. There were 54 grains of silver in the sulphide, and there is therefore but little loss. Experiment by R. Smith. *See* Percy's Metallurgy, Silver and Gold, p. 39.

1752. Result of heating sulphide of silver with cyanide of potassium.

62 grains of sulphide of silver and 248 grains of cyanide of potassium were heated in an open clay crucible. The result is a button of metallic silver weighing 45·4 grains (out of 54 in the sulphide). It is white and finely fibrous in fracture. Over this was a brown-red slag containing sulphide of silver. About five sixths of the silver is therefore reduced. Experiment by R. Smith, 1876. *See* Percy's Metallurgy, Silver and Gold, p. 37.

1753. Result of heating together sulphide of silver and chlorate of potash. (Experiment I.)

62 grains of sulphide of silver and 248 grains of chlorate of potash were heated in a clay crucible to a temperature below redness. Action occurred after 15 minutes. The product is unfused silver weighing 17·95 grains, and slag which darkens on exposure, and contains chloride of silver 23·82, chloride of potassium 60·98, sulphate of potash 14·77 per cent. One third of the silver is thus reduced. Experiment by H. Louis. *See* Percy's Metallurgy, Silver and Gold, p. 40.

1754. Result of heating together sulphide of silver and chlorate of potash. (Experiment II.)

62 grains of sulphate of silver were heated to low redness with 186 grains of chlorate of potash. Violent and almost instantaneous action occurred. The result is a slag with spots of silver. The separable silver weighed 13·45 grains, or nearly one fourth of the total silver in the mixture. There are, however, globules in the slag. Experiment by H. Louis. *See* Percy's Metallurgy, l.c.

1755. Sulphate of silver crystallised from sulphuric acid.

1756. Sulphate of silver after ignition.

A pinkish-brown powder.

1757. Sulphate of silver fused at a temperature just above redness.

It is a yellow liquid when molten and becomes crystalline on cooling. If a little sulphide of silver is present it is orange coloured, as here seen. Experiment by H. Louis. *See* Percy's Metallurgy, Silver and Gold, p. 44.

1758. Silver reduced from sulphate of silver by copper.

A granular mass of loose metallic silver. Experiment by R. Smith.

1759. Selenide of silver.

Produced by fusing 41·6 grains of silver with 15·9 grains of selenium. H. Louis, 1876.

1760. Silver containing 3·75 per cent. of selenium.

25·7 grains of pure silver and one grain of selenide of silver, as above, were placed in a small clay crucible, closed by plug of charcoal, heated for 10 minutes to bright redness, and allowed to cool gradually. The button weighs 26·67 grains. It is moderately malleable and has a crystalline surface. Experiment by H. Louis, 1876. *See* Percy's Metallurgy, Silver and Gold, p. 53.

1761. Silver containing 0·375 per cent. of selenium.

26·6 grains of pure silver and 0·1 grain of the selenide were treated in the same way. The button weighs 26·67 grains. The fracture is whiter, the surface not so crystalline, and the metal is very malleable. Experiment by H. Louis. *See* Percy's Metallurgy, Silver and Gold, p. 53.

1762. Chloride of silver dried to a dirty white powder.

1763. Chloride of silver obtained by exposing silver leaf to the action of chlorine gas.

This is more or less discoloured, very little is white. *See* Percy's Metallurgy, Silver and Gold, p. 61.

1764. Chloride of silver resembling "horn silver."

This is in the form of a thin hard plate, which was found after the lapse of about three weeks at the bottom of a vessel at the Mint, containing a strong solution of nitrate of silver with free nitric acid, to which hydrochloric acid had been added. Communicated by Prof. W. C. Roberts Austen.

1765. Result of fusing together chloride of silver and chloride of sodium.

47·8 grains of chloride of silver and 117 grains of rock salt, *i.e.*, quantities in the ratio of one equivalent of the former to six of the latter, were kept fused at a low red heat for 20 minutes in a glass tube placed vertically in a crucible. The result is highly crystalline, apparently homogeneous with a metallic taste and darkening on exposure to sunlight. Experiment by H. Louis, 1876. *See* Percy's Metallurgy, Silver and Gold, p. 63.

1766. Coins showing the formation of chloride of copper by long exposure to damp earth.

They are of Edward the Confessor's reign, and have become brittle. They are partially coated with a thin crust, leaving the rest of the surface bright. The whole of one coin weighed 21·02 grains. This was washed with ammonia water and the washings analysed, giving the following results:

Original metal - - -	88·36
Chloride of silver - - -	10·50
Oxide of copper - - -	0·73
Oxychloride of copper? - -	0·41
Sulphuric acid - - -	trace
	100·00

Analysis by R. Smith. *See* Percy's Metallurgy, Silver and Gold, p. 87.

1767. Experiment to show the formation of chloride of silver by the action of chloride of copper on metallic silver.

A strip of metallic silver was heated to redness and put into a glass tube containing an aqueous solution of chloride of copper, which was boiled and sealed in hermetically after two years, during which the tube had been more or less exposed to daylight. The solution had become dark, and the strip of silver (here shown) was coated with a dark crust, which is crystalline under a lens. This crust dissolves in aqueous solution of ammonia without turning it blue, and on addition of nitric acid in excess a copious white precipitate of chloride of silver was formed. Experiment by J. Percy, 1853-5. *See* his Metallurgy, Silver and Gold, p. 70.

1768. Experiment to show the formation of chloride of silver by the action of the chlorides of copper and sodium.

The same method was pursued as in the last experiment, but with the addition of salt to the solution. After two years the solution was found to be dark brown, and the silver sheet (here shown) is covered with shining crystalline particles, apparently cubical, much larger than before. It has the consistency of horn silver. It dissolves as before in ammonia, and is precipitated by nitric acid, showing the presence of the chloride of silver. The brown colour of the solution being due to cuprous chloride. Experiment by J. Percy. *See* his Metallurgy, l.c., p. 71.

1769. Result of exposing sulphide of silver, immersed in chloride of copper, to air.

This remained exposed from August 1855 to January 1856, and there is now a light green deposit with portions of the unaltered silver sulphide. This deposit when dissolved in ammonia had a blue colour, and was precipitated by nitric acid, showing it to be chloride of silver. Experiment by A. Dick. *See* Percy's Metallurgy, Silver and Gold, p. 74.

1770. Formation of chloride of silver from sulphate of silver.

104 grains of sulphate of silver and 39 grains of chloride of sodium were kept molten during 15 minutes. The upper and outer band has a pink tint, darkening on exposure to light, and consists mainly of sulphate of soda. The lower layer was at first yellow, but is now dark by exposure to light. It is crystalline, sectile, and horny, and is nearly entirely chloride of silver. Experiment by H. Louis, 1876. *See* Percy's Metallurgy, Silver and Gold, p. 87.

1771. A mixture of silver sulphide, copper chloride, and common salt exposed in solution to the air for five years.

The mixture is now a green liquid and with a white precipitate.

1772. Compound ? produced by the action of silver on mercuric chloride, in proportions to form silver chloride and mercurous chloride.

1773. Sulphide of silver derived from silver chloride.

In the form of a black powder. By acting on the chloride dissolved in sulphate of soda by hydrochloric acid.

1774. Action of sulphide of lead on chloride of silver.

A mixture of these two compounds, in proportion of one equivalent of each, was fused in a hard glass tube at a dull red heat. The fused mass consisted of two layers: the upper one, almost entirely soluble in water, was mostly chloride of lead; the lower layer is black, dense and sectile, soluble in nitric acid, and is mostly sulphide of silver, containing 72·53 per cent. of silver out of the 87·1 per cent. it would contain if it were pure. Experiment by H. Louis. *See* Percy's Metallurgy, Silver and Gold, p. 101.

1775. Bromide of silver formed by acting on silver leaf by the vapour of bromine.

Grey metallic fragments, retaining the form of the leaf.

1776. Result of heating together silver and phosphorus.

To 501 grains of molten silver in a clay crucible, 200 grains of red phosphorus were added in successive portions with stirring. After the surface had become smooth, the metallic mass on cooling rose in the crucible to nearly double its volume, giving out phosphorus vapour. It is vesicular in the upper part and solid underneath. The metal in the upper part is rather yellowish white and crystalline, in the lower part it is clearer white and more solid. The upper part was found to contain 0·293 per cent. of phosphorus, and to contain 0·072 per cent. of phosphorus in addition in the form of phosphoric acid in the cavities. The lower part contained 0·207 per cent. of phosphorus. Experiment by R. Smith. *See* Percy's Metallurgy, Silver and Gold, p. 137.

1777. Silver compound analogous to the purple of Cassius.

If hydrated peroxide of tin is stirred into a thin milky liquid, a neutral solution of nitrate of silver added, and the mixture gently heated, this substance, purplish-brown when dried, is produced, consisting of stannate of tin and stannic hydrate, or possibly of the latter only and metallic silver. Experiment by H. Louis. *See* Percy's Metallurgy, Silver and Gold, p. 128.

1778. Arsenide of silver.

501 grains of silver were melted under charcoal in a clay crucible, and 201 grains of metallic arsenic added in three successive portions. The metallic mass was well stirred till the surface was tranquil and then allowed to cool. The product is hard and brittle, its fracture is granular and slightly crystalline, dark iron-grey, and dull in lustre, but becoming bright by burnishing. It contains silver 81·46 per cent. and arsenic 18·54 per cent., and corresponds therefore approximately to the formula Ag_3As. Experiment by R. Smith. *See* Percy's Metallurgy, Silver and Gold, p. 139.

1779. Compound of three equivalents of silver and one of antimony.

162 grains of silver were melted under charcoal in a clay crucible, and 61 grains of antimony added by degrees. The metal was well stirred, and taken out of the furnace to cool. The product weighed 222·8 grains, showing a loss of two grains. It is harder than silver, its fracture is largely crystalline, and its colour is bluish white. Experiment by R. Smith. *See* Percy's Metallurgy, Silver and Gold, p. 143.

1780. Compound of four equivalents of silver and one of antimony.

216 grains of silver and 61 grains of antimony were operated upon in a similar manner to the last. The product weighed 276 grains, showing a loss of one grain. The colour is greyish white, but otherwise the product resembles the last. Experiment by R. Smith. *See* Percy's Metallurgy, l.c.

1781. Compound of six equivalents of silver to one of antimony.

162 grains of silver and 30·5 grains of antimony were similarly acted on. The product weighed 192 grains, showing loss of ·5 grain. Its fracture is granular and the colour greyish white. Experiment by R. Smith. *See* Percy's Metallurgy, l.c.

1782. Result of heating together oxide of silver and oxide of antimony in atmospheric air.

A mixture of equal bulks of the two oxides was heated to low redness in a glass tube open at both ends, and slightly inclined so that a current of air kept passing through it. The product is a dull greenish-grey mass, which gives reduced silver when heated in a closed tube; 19·165 grains of this on analysis gave 5·315 grains of chloride of silver and 10·713 grains of antimony, corresponding to 22·44 per cent. oxide of silver and 75·87 per cent. antimonic acid. Experiment by H. Louis. *See* Percy's Metallurgy, Silver and Gold, p. 146.

1783. Antimoniate of silver heated.

A greenish-grey powder.

1784. Alloy of silver and antimony in the proportion of one equivalent each.

42 per cent. of silver and 58 per cent. of antimony were heated together, producing a dark grey brittle mass. Experiment by G. H. Hochstätter. *See* Percy's Metallurgy, Silver and Gold, p. 147.

1785. Calcined alloy of silver and antimony.

The alloy produced in the last experiment was finely powdered and heated, with free access of air. The product is brownish yellow, and contains metallic silver. On analysis it contains—

Oxide of silver - - -	0·34
Metallic silver - - - -	37·20
Antimonious acid - - -	62·89
	100·43

Experiment by G. H. Hochstätter. *See* Percy's Metallurgy, l.c.

1786. Alloy of silver and antimony calcined with ferrous sulphate.

A mixture of 50 grains of the finely powdered alloy (prepared as in No. **1784**) and 20 grains of dry ferrous sulphate was calcined in air. The product is a dark brown powder, containing metallic silver. Its analysis gives—

Metallic silver - - - -	30·92
Ferric oxide - - - -	15·23
Antimonious acid - - -	53·90
	100·05

1787. Metal produced in an attempt to prepare silicide of silver.

Contains 92·04 per cent. of silver, 4·90 per cent. of lead, 0·15 per cent of aluminium, and 2·77 per cent. of uncombined silicon. Experiment by L. Jackson, 1875.

SILVER ORES.

1788. Silver ore from Avrastras, Real del Monte.

1789. Silver ore for amalgamation.

Contains 171 oz. 3 dwt. 21 gr. to the ton.

1790. Pyrargyrite, ground, a sulphide of silver and antimony.

1791. Proustite, ground, a sulphide of silver and arsenic from Marienberg.

1792. Silver ore from Valparaiso.

Containing 30 per cent. of silver in the form of ground chloride ; also some arsenic.

1793. Fused chloride of silver from Africa.

Probably from sand containing it. Communicated by Rose, Norton, and Co.

1794. Silver-lead ore from Spanish Mine, Bingham Cañon, Utah.

A soft grey stone.

1795. Silver-lead ore from Davenport Mine, Little Cottonwood District, Utah.

A dark heavy sub-metallic mass.

1796. Silver-lead ore from Miner's Delight Mine, East Cañon, Ophir Mining District, Utah.

Grey and scoriaceous.

1797. Silver ore from McHenry's Mine, Parley's Park Cañon, Utah.

Grey and sub-metallic. Communicated by the Utah Mining Company.

1798. Mass of brown quartz showing crystals of native silver. New South Wales.

1799. Silver-lead ore from San Juan Mine, Mexico.

Analysed by R. Smith. Contains 63 per cent. of lead and 44 oz. 3 dwt. 17 gr. silver to the ton of ore. Communicated by Stevenson Forbes, Llandudno.

1800. Silver ore from Morning Star Mine, Butte, Montana.

In a gangue of pyritous quartz. In 1881 this mine had produced 600 tons of ore, containing 135 oz. silver and 1½ oz. gold to the ton. Communicated by W. A. Clarke.

1801. Ore containing zinc, copper, and iron. Butte, Montana.

Dark and sub-metallic, yields 160 oz. silver to the ton. Communicated by W. A. Clarke.

1802. Silver ore from Mintton Mine, Butte, Montana.

Massive and speckled. Produce $45 worth of silver per ton.

1803. Silver ore. Lexington Mine, Butte, Montana.

An earthy gossan. Communicated by W. A. Clarke.

1804. Ruby silver ore from Sheridan Mine, San Miguel County, Colorado, U.S.A.

In a massive quartzose gangue.

1805. Silver ore from Mexico.

Earthy brown ore containing sulphide of silver, in the rough state; some is ground to powder for the purposes of amalgamation.

1806. Silver chloride ore, or horn silver.

From "Big Pittsburg Mine," Leadville, Colorado, U.S.A.; very rich in chloride of silver. Heavy, brown, and earthy. Communicated by Dr. Johnson.

1807. Silver ore from Little Sliver Mine, Leadville, Colorado, U.S.A.

Brown and ochreous. Contains chloride of silver.

1808. Silver ore from Robert E. Lee Mine, Leadville, Colorado, U.S.A.

Red and ochreous. Contains chloride of silver.

1809. Bismuth-silver ore from the Geneva district, Colorado.

A dark grey brecciated vein.

THE SMELTING OF SILVER ORES.

SERIES of SPECIMENS showing the Method of Silver-working at the Morfa Silver Works, South Wales. Supplied by the late Richard Pearce when Manager, 1869.

1810. Mixed silver ore ground to powder.

This contains about 400 ounces of silver to the ton. It is smelted with the two succeeding specimens.

1811. Crushed slag metal.

This consists of dark fragments derived from the silver-ore slag after smelting it with mundic. It forms part of the mixture for the primary smelting.

1812. Gossan.

Surface-weathered product, used to form part of the mixture for the primary smelting of the ores.

1813. Silver metal regulus.

20 cwts. of mixed silver ore, 10 cwts. of crushed slag metal, and 5 cwts. of gossan are smelted together, and the products are this black porous regulus, containing about 2·5 per cent. of silver and 10 per cent. of copper, and the following slag.

1814. Silver-ore slag.

Accompanying the regulus No. **1813.** A black glass taken from the top of the slag where rapid cooling occurs.

1815. Silver-ore slag.

Accompanying the regulus No. **1813.** Taken from the middle of the slag. It contains, on an average, about 10 ounces of silver to the ton. Massive, black, and vacuous.

1816. Mundic to smelt with the silver-ore slag.

The products are the slag metal used in the primary smelting, and the next substance.

1817. Slag from smelting silver-ore slag (Nos. **1814, 1815**) with mundic (No. **1816**).

A massive, black, compact slag, said to be clean, *i.e.*, not to contain any metal worth extracting.

The final product of the smelting process is No. **1813**; this is then treated by Ziervogel's process for the extraction of the silver as sulphate.

1818. Silver-metal regulus, ground and passed through a sieve of 60 holes to the linear inch.

1819. Ground silver-metal regulus calcined for eight hours.

The silver which is present in the form of sulphide is thus converted into a soluble sulphate, while the copper, iron sulphides, &c. with which it is contaminated become sulphates sooner, and are now converted into insoluble oxides.

1820. Residue after washing No. **1819** with hot water for about 12 hours.

The sulphate of silver is by this washing extracted in a soluble form, and this residue contains about ·20 per cent. only of silver (= 65 oz. to the ton) and 10 per cent. of copper.

1821. Silver in flakes as precipitated from the solution of the sulphate by plates of copper.

1822. Silver precipitate after washing with dilute sulphuric acid.

This washing separates the copper and copper oxide, and the residue, a clear silver-white powder, is fit for melting, and should contain 99·80 per cent. of silver.

The larger amounts of silver having thus been extracted, further processes are resorted to for the extraction of the residue, and the metal contained in poorer ores; the following 15 specimens (Nos. **1823** to **1837**) illustrate this process. They are all communicated by Mr. R. Pearce, of the Morfa Silver Works, South Wales.

1823. Mixture of argentiferous ores, raw and calcined.

This contains about 5 per cent. of copper and 4 to 5 oz. of silver to the ton. This is mixed with "sharp" slag (*see* No. **1829**) in the proportion of 30 cwt. of the former to 5 cwt. of the latter.

1824. Ore metal from smelting No. **1823.**

It is solid, sub-metallic, with a brownish lustre, and is full of cavities; it contains about 38 per cent. of copper and 30 oz. of silver to the ton.

1825. Slag accompanying the ore metal, No. **1824.**

It is a crystalline black slag with small cavities, and is thrown away as worthless.

1826. Ore metal (**1824**) crushed and calcined during 30 hours.

1827. White metal.

This is obtained by smelting No. **1826** with siliceous argentiferous ore rich in copper, or "cobbing" (old bricks, &c.). It is black, heavy, and glistening, and usually contains about 70 per cent. of copper and 80 oz. of silver to the ton, in the form of sulphides.

1828. Sharp slag.

A solid mass without grain or obvious crystallisation, except at the surface, which is covered with a loose aggregation of arborescent crystals, in the form of minute octahedra of magnetite (?), with a few brown transparent plates of iron-silicate.

1829. Sharp slag.

This is the other product which accompanies No. **1827.** It is blue black, brilliantly metallic, with crystals in the cavities, and is used for the primary smelting in this process. *See* No. **1823.**

The white metal is then subjected to Ziervogel's process for the extraction of the silver as sulphate.

1830. White metal crushed previous to calcination.

1831. Crushed white metal after calcination for 24 hours.

1832. Calcined white metal, ground and passed through a sieve with 80 holes to the linear inch.

1833. The ground calcined white metal recalcined for the production of sulphate of silver.

This has been calcined four additional hours, whereby the silver sulphides become sulphates, and the already produced copper sulphates become oxides.

1834. Residue after washing out the sulphate of silver.

It usually contains about 24 oz. of silver to the ton, which has not been converted into sulphate by the process. The sulphate is treated with copper plates as before. This residue is then subjected to Augustin's process for the extraction of the silver as chloride.

1835. Product of the calcination of No. **1834** with salt for the production of chloride of silver.

1836. Residue after washing No. **1835** with strong hot solution of salt.

This salt solution removes the silver chloride, and this residue contains about 6 oz. silver to the ton.

1837. Silver precipitated as a grey powder from chloride solution by copper plates.

It is afterwards boiled with hydrochloric acid, to separate copper and lead. This is the final product of the process, and is melted with the silver obtained by precipitation in the Ziervogel process.

1838. Blister copper obtained by melting the residue (No. **1836**) with coal.

It is sent to the copper works. For the whole process thus illustrated, *see* J. A. Phillips' Mining and Metallurgy of Silver and Gold, p. 409, &c.

1839. Four varieties of regulus obtained by smelting various South American silver ores at Liverpool.

They contain a great variety of metals, and are not further dealt with in the works where they are smelted. They are all reduced to powder.

1840. Argentiferous regulus for the Ziervogel and Augustin processes.

Two specimens from Morfa Silver Works, 1869, really duplicates of No. **1827**, but of rather different aspect. One is massive, with brilliant platy crystals; the other compact dark brown, with cavities.

1841. Matt from smelting mixed silver ore.

No locality given. A speiss-like 1-inch slab with irregular cavities.

1842. Slag from smelting silver ore in the flowing furnace.

Ground to a coarse black powder.

1843. Slag from Grant Smelting Company, Leadville.

Very solid, and with a brown lustre.

1844. Regulus from smelting silver ores.

It is speiss-like, with irregular cavities, in a 1½-inch slab. It consists of sulphides and arsenides of iron, &c.

1845. Slag from smelting argentiferous residues from zinc pots.

The zinc is derived from blende, and iron pyrites is used to collect the silver. Two specimens of dull opaque, semi-vitreous substance, with a scoriaceous surface.

1846. Argentiferous and auriferous copper matt.

A solid, crystalline, sub-metallic mass, called "white metal," ready for "stripping." Black Hawk, Colorado.

1847. Argentiferous copper matt.

A thick copper slab, scoriaceous in parts, called "purple metal," after stripping the white metal. Black Hawk, Colorado.

1848. Gold and silver regulus slag.

Produced in the process of smelting "sweeps" from gold and silversmiths' shops. At Betts' Refinery, Birmingham, 1845. It consists of a compact matt below, and a coating of reddish-black glass above.

1849. Lead slag used in gold and silver sweep refining at Betts' Refinery, Birmingham.

It contains a certain amount of lead, and this extracts the gold and silver from the "sweep" on smelting. It is grey, earthy, and scoriaceous, with crystals in the cavities, and is probably from Derbyshire. *See* No. **1488.**

1850. Slag from "sweep" refinery.

From Bett's Works, Birmingham. Contains numerous black acicular crystals. These appear to be the crystals measured by Professor Miller, and described by Dr. Percy in the Report for 1846 to the British Association on Crystalline Slags. They belong to the oblique system, and are not identified with any known mineral.

AMALGAMATION PROCESSES.

1851. Roasted ore ready for amalgamation. Freiberg.

A brown powder.

1852. Silver amalgam squeezed.

Contains one-sixth part of silver, and is now ready for retorting. Comstock Mines. Communicated by R. J. Frechville.

1853. Crude bullion, or retorted amalgam.

From "Crown Point Mine," Comstock Lode, Nevada, U.S.A. A rough button, containing about 94 per cent. of silver and 4 per cent. of gold. Communicated by R. J. Frechville.

1854. Silver obtained as a solid button by heating the solid amalgam.

Mexican amalgamation method.

1855. Arborescent silver, "Ausglich silber."

Solid below, with parallel black stalactites. From the Halsbruckner Amalgamation Works, Freiberg.

REFINING SILVER BY CUPELLATION.

1856. "Vegetable silver."

This has "spit" into a remarkable rose-like form. In the process of refining silver by mixing it with lead, and then cupelling, the silver, as it becomes refined, absorbs a large quantity of oxygen, and towards the end of the process this oxygen is given out again like steam from water, and throws the silver into fantastic shapes. From the Black Hawk Silver Works, Colorado, 1875. For an account of this form of silver, *see* Percy's Metallurgy, Silver and Gold, p. 14. Communicated by R. Pearce.

1857. Refined silver, in an irregular cup-like form, of a brilliant metallic white.

This has spit in a similar manner. In the accompanying tube is shown the trace of gold obtained from 102·13 grains of this silver.

1858. Two cupel buttons of silver.

ABNORMAL PRODUCTS IN SILVER WORKS.

1859. Slag containing reduced silver in hollow cavities.

No history is attached to this; it is dark, earthy, porous, and brown.

1860. Silver-ore slag, containing arsenious acid and metallic arsenic.

A black cinder-like mass, with crystalline arsenic in small cavities. From the Morfa Silver Works, 1869. *See* No. **1815.** Communicated by R. Pearce.

1861. Silver-ore slag, containing metallic arsenic in cavities on the surface.

This slag was formed from smelting silver ores, containing a large quantity of arsenic; it was tapped from the furnace, and allowed to remain in the bed for 36 hours. It is accompanied by small selected crystals of arsenic. Morfa Silver Works, 1866. Communicated by R. Pearce.

1862. Argentiferous and auriferous copper matt.

"Coarse metal." From Boston and Colorado Works, Black Hawk, Colorado. Compact, brown, sub-metallic, with fine holes. This and the eight following (Nos. **1863–1870**) were all communicated by R. Pearce, 1875.

1863. Furnace bottom product containing free gold visible in the cracks of the compact rock.

Black Hawk, Colorado. (Three specimens.)

1864. Furnace bottom product containing metallic, brilliant white plates and octahedra in a thin sheet.

Black Hawk, Colorado.

1865. Furnace bottom product with purple-tarnished octahedral crystals in small cavities.

Black Hawk, Colorado.

1866. Argentiferous copper matt with the surface showing octahedral crystals.

Black Hawk, Colorado.

1867. Argentiferous and auriferous copper matt with the surface showing arborescent crystals, arranged in skeleton octahedra.

Boston and Colorado Works, Black Hawk, Colorado.

1868. Crystals from a silver-smelting furnace bottom.

They came from immediately above the brickwork of the arch forming the vault of the furnace, below the furnace bottom proper, and from a part that had not been disturbed for five or six years. The crystals are partly dark octahedra, resembling bornite, and partly brilliant white platy crystals, a rough analysis of which gives silver 40 per cent., lead 40 per cent., and gold 3 per cent. Black Hawk, Colorado.

1869. Artificial galena.

From a furnace bottom, smelting silver ores at Black Hawk, Colorado. The furnace bottom is composed of pieces of gneiss, in the interstices between which the galena is also found.

1870. Artificial galena with white crystals on the surface.

From Black Hawk, Colorado. Compare No. **1868.** The galena crystallises perpendicular to the surface of a dark stony mass.

1871. Crystals resembling olivenite from a furnace bottom.

They are from a metal furnace bottom which had been working five years, and are formed on some bricks immediately resting on the arch supporting the bottom. Two specimens showing a bluish incrustation of small crystals. From the Morfa Silver Works, Swansea, 1870. This and the following eleven (**1872–1882**) were all communicated by R. Pearce.

1872. Artificial copper pyrites from a furnace bottom.

The massive dark yellow crystalline substance has the appearance, specific gravity, and composition of copper pyrites. It is from an ore furnace which had been in work four years, and occurred sparingly in some vertical joints and fissures. Morfa Silver Works, 1870.

1873. Substance resembling copper pyrites from a furnace bottom.

Morfa Silver Works, 1870. It is a cracked mass of matt, the surface of the cracks and of some stalactitic droppings are coloured a metallic yellow, but this appears to be superficial.

1874. Furnace bottom product.

Morfa Silver Works, 1870. A calcined lump showing green radiating crystals of some copper salt.

1875. Substance resembling iron pyrites from a furnace bottom.

Morfa Silver Works, 1870. Compact and massive, of a rather dull brownish-yellow colour.

1876. Crystallised sharp slag.

The surface mainly consists of brilliant flat plates overlapping each other, and arranged so as to form a hollow box with prismatic edges. Here and there on the surface are clusters of dull octahedra. It thus resembles the crystalline forms of the silicates of iron formed in iron furnaces. From Morfa Silver Works, 1870.

1877. Crystallised sharp slag.

The whole of the surface is covered with needle-like outgrowths, each of which is composed of a large number of superposed octahedral crystals, possibly of magnetite, but having a peculiar tarnish. From Morfa Silver Works, 1870.

1878. Speiss from an old furnace bottom at Morfa Silver Works.

The long prismatic crystals resembling stibnite have a specific gravity of 7·308, and have been analysed by Mr. Holdich at the Morfa Works, and yield—

Arsenic - - - -	43·75
Antimony - - - -	20·95
Copper - - - -	12·50
Iron - - - - -	12·85
Nickel and Cobalt - - -	4·90
Bismuth, Lead, and Silver - -	3·00
Sulphur - - - -	2·30
	100·25

1879. Another example of a similar speiss.

In this case the brilliant prismatic crystals are interspersed with and overgrown up some dull tinted arborescent crystals. Morfa Silver Works, 1870.

1880. Black scale-like crystals on the surface of a furnace-brick.

It is suggested that these crystals are oxide of copper pseudomorphous after chloride of copper. They occurred on the surface of and impregnating old bricks which formed part of a salting calciner at the Morfa Silver Works, 1869.

1881. Crystals of cupreous oxide formed on the surface of the copper plates used to precipitate silver from its sulphate solution.

They are scales off the plates, with a minutely crystalline surface.

From the Morfa Silver Works, 1869.

1882. Piece of one of the wooden precipitation vats at Morfa Silver Works, after incineration, 1871.

The silver is precipitated in the fibres of the wood, and this is afterwards incinerated, and a large quantity of silver recovered. The specimen is therefore a model in silver of all the vessels and cavities in the substance of the wood.

1883. Furnace product from a silver reduction works at Salt Lake City, United States.

Communicated by E. S. Blackwell, 1874. Brilliant crystalline plates standing erect, and composed of numerous smaller hexagonal and rectangular plates. They are a mixture of lead, copper, zinc, and silver.

1884. Crystals believed to be disulphide of copper.

From one of the furnace bottoms at the Boston and Colorado Silver Smelting Works, Denver, 1880.

1885. Crystals of red oxide of copper artificially produced.

These minute crystals were found in clusters attached to the sides of a wooden cistern, which was used for the recovery of the last traces of silver from the solution of the sulphate in Ziervogel's process. They are one year's growth, the cistern being annually cleaned, the temperature being pretty constant from 180° to 200° Fahr. Boston Silver Smelting Works, Denver, 1880.

1886. Artificially crystallised copper.

Minute pieces coated with grey dust obtained from one of the bottoms of the furnaces used for roasting white metal for the concentration of the gold. Boston Silver Smelting Works, 1880.

1887. Two specimens of a brilliant crystalline furnace bottom alloy.

Produced in the smelting furnaces of the Boston and Colorado Smelting Company, Colorado, 1883. It consists of outgrowths, of octahedra and octahedral plates, sometimes in spear-like forms, sometimes in rectangular or oblique arborescent form. Roughly analysed, it consists of gold 19·88 per cent., silver 39·07 per cent., and lead 41·05 per cent.

1888. Brick from calcining furnace showing absorption of silver.

This was taken from the bottom of a calcining furnace which was employed for some weeks in oxidising a granulated alloy containing 84 per cent. of copper and 16 per cent. of silver. The heat used was at no time above a good cherry-red heat, sufficient to completely oxidise the copper. The brick contains 4·2 per cent. of silver, and 3·6 per cent. of copper. Communicated by J. F. Williams. From Llanelly Lead Works, 1883.

1889. Clay between the bricks of a calcining furnace showing absorption of silver.

This is the intervening material between the bricks, No. **1888.** In this case the clay has absorbed 8·5 per cent. of silver and 3·6 per cent. of copper. These specimens point to the conclusion that the silver is extracted in the form of aluminate or silicate by the porous clay and brick, but little copper being taken with it, and that the unburnt clay has a stronger action in this respect than the brick. Llanelly Lead Works, 1883. Communicated by J. F. Williams.

THE METAL IN VARIOUS FORMS.

1890. "White Pine" silver bullion cast into an ingot.

From the White Pine Mine, Comstock Lode, Nevada, U.S.A. Contains 99·5 per cent. of silver, weight 12·83 oz. Communicated by R. J. Frecheville.

1891. Silver precipitated from the sulphate in irregular pieces.

1892. Silver specially purified.

In a precipitated granular form, prepared by A. Dick.

1893. Silver purified by cupellation, in a solid button.

1894. Silver showing columnar fracture.

Melted silver was poured at the Morfa Silver Works into an open mould of the usual shape, and fractured by a blow of a hammer. Near the upper edge of the fracture, in the neighbourhood of the point of percussion, the metal consisted of a confused aggregate of imperfectly formed octahedral crystals (upper specimen), elsewhere it is fibrous and columnar, the fibres nearly perpendicular to the sides and bottom of the ingot (lower specimen). *See* Percy's Metallurgy, Silver and Gold, p. 3.

1895. Purified silver in the form of a button containing 99·76 per cent. silver and ·1 per cent. gold.

1896. Figure in "Pina silver" from Mexico.

Weight, 5 ounces 264 grains, 1879.

1897. Pure silver wire.

1898. Silver leaf.

Showing the tarnishing it suffers on exposure.

ALLOYS OF SILVER.*

1899. Alloy of 95 parts of silver to 5 of aluminium.

1900. Alloy of silver and zinc, containing 0·18 per cent. of silver.

600 grains of zinc were heated to as near the melting point of the metal as possible, and 12 grains of silver added. After half an hour the silver on cooling was found in its original solid state at the bottom, hence at this temperature very little solution of silver takes place. Experiment by G. H. Godfrey, 1870. *See* Percy's Metallurgy, Silver and Gold, p. 169.

1901. Alloy of silver and zinc, containing 8·16 per cent. of silver.

Produced by heating 600 grains of granulated zinc and 60 grains of granulated silver to strong redness under charcoal for half an hour. It has a specific gravity 7·44. It is bluish grey, hard, brittle, easily scratched with a knife, and with a granular fracture. Experiment by G. H. Godfrey. *See* Percy's Metallurgy, Silver and Gold, p. 170.

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* Exclusive of those with arsenic and antimony.

1902. Alloy of silver and zinc, containing 22·47 per cent. of silver.

Produced by pouring molten zinc into molten silver, when violent action ensued. It has a specific gravity 7·62 is bluish grey, harder than No. **1901**, brittle, less easily scratched, with a bright fibro-columnar fracture. Experiment by G. H. Godfrey. *See* Percy's Metallurgy, l.c.

1903. Alloy of silver and zinc, containing 49·72 per cent. of silver.

Produced in the same way as No. **1902.** It has a specific gravity 8·61, and is copper-red on the surface and fracture when hot, but white and bright when cold. It is very hard and brittle, the fracture is foliated or columnar, inclining to conchoidal. Experiment by G. H. Godfrey. *See* Percy's Metallurgy, l.c.

1904. Alloy of silver and zinc, containing 67·58 per cent. of silver.

Produced in the same way as No. **1902.** It has a specific gravity 9·30. It has a faint yellowish tinge, and is hard and brittle. Its fracture is columnar, and its colour is white at first, but tarnishing to yellow. Experiment by G. H. Godfrey. *See* Percy's Metallurgy, l.c.

1905. Alloy of equal parts of silver and thallium.

Made by Mr. Crookes, 1876. The two metals readily fuse together; the alloy is somewhat, but not completely malleable. They are easily separated on a cupel, the thallium very rapidly oxidising, as on this specimen; when the surface is freshly scraped, the colour is white. *See* Percy's Metallurgy, Silver and Gold, p. 175.

1906. Semi-liquid amalgam of silver and mercury.

Obtained in experimenting on South American ores.

1907. Solid amalgam of silver and mercury.

1908. Alloy of two parts of silver and one of platinum.

Used by dentists for artificial palates, and also as a standard of electrical resistance, &c. Prepared in sheet by Johnson, Matthey, and Co. *See* Percy's Metallurgy, Silver and Gold, p. 182.

1909. Alloy of silver [and platinum ?].

Annealed, and unannealed, after rolling into a sheet, like the last.

1910. Alloy of three parts of silver and one of palladium.

Rolled out into a very thin sheet. It does not blacken by sulphuretted hydrogen, but these specimens are much tarnished. *See* Percy's Metallurgy, Silver and Gold, p. 182.

1911. Silver containing gold and iridium.

In a small thin sheet from Messrs. Betts' Refinery Works, Birmingham. Silver is said to form no alloy with iridium alone. *See* Percy's Metallurgy, Silver and Gold, p. 183.

1912. Filings of an alloy of silver and tin.

Used to form an amalgam with a small quantity of mercury for stopping teeth, sold as Smale's Dental Compound. It is said to contain 60 per cent. of silver and 40 per cent. of tin.

1913. Alloy of silver with 20 per cent. of magnesium.

Prepared by J. Parkinson in rock salt and fluor-spar. It has a yellowish tint, and cracks on being beaten out. *See* Percy's Metallurgy, Silver and Gold, p. 188.

1914. Alloy of silver containing 10 per cent. of magnesium.

In a small yellow tarnished button. *See* Percy's Metallurgy, l.c.

1915. Alloy of silver and cadmium.

Used for graduated scales of philosophical instruments. Analysed by R. Smith.

Silver - - - - -	86·66
Copper - - - -	0·02
Cadmium - - - -	13·34
Gold - - - - -	0·02
	100·04

See Percy's Metallurgy, Silver and Gold, p. 668.

1916. Alloy of silver and gold in a plate, such as is used for parting.

Made by Johnson, Matthey, and Co.

1917. Alloy of 49 parts of silver to 51 of copper.

Yields by cupellation 48·3 of silver. Made by R. Smith, and beaten into a sheet.

1918. Alloy of 89 parts of silver to 11 of gold.

Made by R. Smith, and beaten into a sheet.

1919. Alloy of 32 parts of silver with 51 parts of copper and 17 of gold.

Made by R. Smith, and beaten into a yellowish sheet.

1920. Alloy of 10 parts of silver with 45 of tin and 45 of lead.

Made by R. Smith, and beaten into a sheet, now tarnished.

Alloys of Silver in Use.

1921. Rolled out United States dollar, 1839.

Yields 90·1 per cent. of silver by cupellation. Experiment by R. Smith.

1922. Rolled out riksdaler.

Yields 87·4 per cent. of silver by cupellation. Experiment by R. Smith.

1923. Spanish dollar.

Contains 22·58 per cent. of silver by wet assay; 22·62–22·65 by cupellation.

1924. Piece of Mexican dollar.

Shows lamination produced in casting, and therefore thought to be spurious. Yields 91 per cent. of silver.

1925. Chinese "chopped" dollar.

The Chinese being great adepts at forging coins, each possessor of a coin punches his name or "chop" on the coin, so that the value may be demanded if it turn out to be spurious. This is so chopped over as to become concave. A Chinaman who is pitted from small-pox is called a "chop-dollar."

1926. The ring or milling of a Spanish dollar from which the interior has been removed by "chopping."

The small bits which are detached after repeated chopping are used by the Chinese as a medium of exchange for rice, &c., until they are received by the bankers, who send the accumulated fragments to the refiners for conversion into Sycee silver.

1927. Mexican dollar rendered fraudulent by the Chinese.

One face of the coin is sawn off near its under surface; the whole thickness of the inside of the coin is then scraped out, and the place of the silver supplied by some base metal, in this case by lead; the upper surface of the coin is then hammered on again, and the outside appearance of the coin is in no way affected.

1928. A similar coin rendered fraudulent by filling the interior with copper.

1929. A similar coin rendered fraudulent by filling the interior with brass.

1930. Fragments of a Mexican dollar in the process of being made fraudulent by the insertion of lead.

The above six Chinese specimens and the information regarding them were communicated by Mr. C. Tookey, late assayer to the Hong Kong Mint.

1931. A silver dollar of Charles II. of Spain, struck in Mexico in 1781.

Found on the Chesil beach in 1878, after having been lost in the sea. It is now coated with an oxide, the nature of which has not been determined.

1932. Mexican dollar acted on by sea water.

It was taken from the steamer "Pacha" five years after she was wrecked in the straits of Malacca. All the silver, amounting to 50,000*l*. worth, was covered by a thick coating of sulphide, of which specimens are here. Procured by Dr. Boycott.

1933. Coin of the 17th century.

Communicated by Mr. Hawkins. Analysed by R. Smith, contains 23·72 per cent. of silver and ·05 per cent. of gold.

1934. Part of a silver vase from Mycenæ.

Procured by Dr. Schliemann. The fragment weighed 44·36 grains in all. It is a thin convex plate, with a weathered crust in two layers, a dark one next the metal, and a lighter one outside. Part of the crust, soluble in ammonia, consisted principally of chloride of silver with a little black oxide of copper. The insoluble portion was less in quantity, consisting chiefly of silver and carbonate of lime. The relative weights were metal 74·66, soluble crust 21·97, insoluble crust 3·16=99·79. The original metal is supposed to have had the following composition:—

Silver - - - -	95·59
Gold - - - - -	0·30
Copper - - - -	3·23
Lead - - - - -	0·44
Iron - - - - -	0·12
	99·68

For full description, *see* Schliemann, Mycenæ and Tiryns. Appendix by Dr. Percy, No. III., p. 370.

GOLD.

Experiments on Gold.

1935. Specimens of charcoal showing its reducing action on chloride of gold.

These sticks of charcoal were immersed in water, and 32·50 grains of gold in the form of chloride were added on August 7, 1869. 85 more grains of gold in the form of chloride were added on November 3, 1869, and the bottle has been left to stand. The surface of the charcoal is now coated over with metallic gold.

1936. Gold precipitated from its chloride by means of charcoal.

This is a model in gold of the surface of the end of a stick of charcoal left immersed in a strong solution of chloride of gold. The fibres and vessels of the stem are all shown on the surface of the metal.

1937. Auriferous copper before and after trituration.

Specimens in Glass Tubes to show the wide Distribution of Gold.

They are small specks of gold, of various sizes, gummed to paper.

1938. Gold from 2,000 grains of Pattinson's crystallised lead.

1939. Gold from 2,000 grains of "Longelwyks "uncrystallised lead.

1940. Gold from 2,000 grains of lead from Tuscany called "Coridi.".

1941. Gold from 2,000 grains of lead called "Pzribramer Hartblei."

1942. Gold from 2,000 grains of lead called "Pzribramer Weichblei."

1943. Gold from 2,000 grains of lead called "Bleiberger Probierblei."

1944. Gold from 300 grains of dried lead fume.

Sample No. 1. From Alport Lead Works, Derbyshire.

1945. Gold from 300 grains of dried lead fume.

Sample No. 4. From Alport Lead Works, Derbyshire.

1946. Gold from 500 grains of lead ore.

1947. Gold from 4,000 grains of lead obtained from Pattinson's oxychloride of lead.

Two examples to obtain the mean.

1948. Gold from 2,000 grains of lead obtained from red lead manufactured from Snailbeach lead, Shropshire.

1949. Gold from 2,000 grains of lead from red lead, prepared from Derbyshire lead ores.

1950. Gold from 2,000 grains of lead obtained from litharge.

1951. Gold from 2,000 grains of lead obtained from litharge.

Sample No. 2.

1952. Gold from 2,000 grains of lead obtained from litharge.

Sample No. 3.

1953. Gold from 2,000 grains of lead obtained from litharge.

Sample No. 4.

1954. Gold from 2,000 grains of lead obtained from white lead.

1955. Gold from 2,000 grains of lead obtained from white lead.

Sample No. 2.

1956. Gold from 4,000 grains of lead obtained from carbonate of lead.

The carbonate of lead was obtained by precipitating nitrate of lead by carbonate of soda.

1957. Gold from 4,000 grains of lead obtained from acetate of lead.

1958. Gold from 4,000 grains of lead obtained from acetate of lead.

Sample No. 2.

1959. Gold from 4,000 grains of lead obtained by precipitation from acetate of lead by zinc.

1960. Gold from 2,000 grains of lead forming part of a lead pipe used at the Exhibition of 1851.

1961. Gold from 770 grains of lead.

1962. Gold and silver from 100 grains of lead ore.

1963. Gold from 100 grains of iron pyrites with 800 grains of lead.

1964. Gold from 100 grains of copper sheathing from H.M.S. "Hound."

Put on May 1846, taken off September 1849. The copper was cupelled with 1,700 grains of lead obtained by precipitation from carbonate of lead. A portion therefore of the gold may have been obtained from the latter source, and not from the sheathing. *See* No. **1956.**

1965. Gold from 10 grains of copper sheathing of H.M.S. "Hound" after the corroded surface had been removed.

The sheathing was on the vessel from May 1846 to September 1849. It was cupelled with 150 grains of lead obtained from acetate of lead. To obtain the amount derived from the sheathing, this sample must be compared with Nos. **1957–1959,** remembering the amounts taken in each case.

1966. Gold from 10 grains of the portion removed by scraping the copper sheathing taken from H.M.S. "Hound."

Cupelled with 150 grains of lead obtained from nitrate of lead. *See* **1956**, comparing the quantities taken. The sheathing was on from 1846 to September 1849.

1967. Gold from 100·460 grains of silver.

1968. Gold from 2,000 grains of bismuth.

1969. Gold from silver ore.

500 grains of the ore were treated in different ways. Sample No. 1 is the amount from an alloy obtained by fusing the ore. The other one marked III. is the amount from an alloy obtained by scorification. The third sample marked IV. is the amount of gold obtained by a similar process to No. 3, when the silver has been removed.

All these results on the distribution of gold in small quantities have been obtained by Mr. R. Smith in 1855, &c.

ORES OF GOLD.

1970. Auriferous iron sand from Africa.

From the River Lombige district of Golungo Alto, about 150 miles to the interior of Loanda, capital of Angola, West Coast of Africa. The sand is taken from the "rocker" which is washed in bowls called "peats," to get the gold dust. Obtained in 1868 by J. J. Monterio.

1971. Auriferous rock from the Effuenta Mines, Wassan Country, Gold Coast, West Africa.

Numerous particles of gold are visible under a lens in the largest of the three specimens. They are schists containing a large quantity of titaniferous iron. Brought by E. T. Macarthy, 1881.

1972. Gold quartz from Denkera Country, Gold Coast, West Africa.

The gold is in visible quantities. Brought by E. T. Macarthy 1881.

1973. Rock supposed to contain gold from California.

Communicated by F. Calderwood.

1974. Crushed gold quartz, not washed nor amalgamated, from Californian Mines.

Communicated by F. Calderwood.

1975. Tailings from the mill at the Californian Mines.

This is what is carried away by the water employed, and deposited some little distance on in the bed of the stream. Communicated by F. Calderwood.

1976. Fine tailings from the mill at the Californian Mines.

This contains 20 oz. 11 dwt. 11 gr. of silver and 2 oz. 16 dwt. 3 gr. of gold to the ton. Communicated by F. Calderwood.

VARIOUS FORMS OF THE METAL.

1977. Assay gold.

Prepared by Messrs. Johnson and Matthey in 1871. Said to be prepared by oxalic acid acting on chloride of gold. The metal obtained has been fused and run into an ingot, and part has been rolled out. The fineness has been examined at the Royal Mint, and it is found to be as nearly as possible pure gold.

1978. Book of gold leaf.

1979. Wire of pure gold. Weight 135 grains.

1980. Moss gold from New South Wales.

An arborescent mass, somewhat resembling in form the moss copper of the smelters. Communicated by A. Liversidge in 1877.

1981. Hollow globule of gold mounted as a microscopic object.

It shows numerous cracks or sub-divisions on its surface. Communicated by Mr. Makin in 1872.

1982. Assay gold.

Prepared by W. C. Roberts (now Professor W. C. Roberts-Austen) at the Royal Mint in 1871. It has been thrown down from chloride of gold by sulphurous acid, and afterwards melted into an ingot and rolled.

1983. Pure gold.

Made by C. Tookey in Hong Kong, when he was assayer to the Mint there.

1984. Gold leaf which has been overheated.

Accompanied by a box containing the same kind of gold leaf before it was heated. No further details accompany these specimens.

1985. Pottery gold, as used by Messrs. Minton for gilding china ware.

1986. Gold in the form of fine, rich brown powder.

It has been precipitated from its chloride by ferrous sulphate. Such gold in powder is used in china works for gilding china. It has to be incorporated with an oily liquid. This sample was not found to incorporate well, and could not be used for the purpose.

1987. Gold in fine, rich brown powder, obtained from its sulphide.

1988. Gold precipitated by sulphurous acid.

1989. Gold precipitated by ferrous sulphate.

1990. Gold precipitated by Ash's precipitater.

1991. Crystallised gold.

Showing obscure outlines of octahedra.

1992. Gold precipitated by oxalic acid.

On one side it is loosely aggregated and dull; on the other, more closely compacted and brilliant.

1993. Gold precipitated by oxalic acid.

In very minute crystals.

1994. American sponge gold.

It is deposited in very minute, loosely aggregated fibres.

The above specimens (Nos. **1988-1994**) are microscopic slides, and were all communicated by Mr. Makin, 1872.

1995. Gold crystals obtained from amalgamation works.

These crystals were found in the mercury troughs at the foot of the blanket strikes, in an amalgamation works. The troughs are placed to catch any stray particles of gold that might pass the blankets. The amount of gold, however, recovered in this way amounting only to $\frac{3}{4}$ grain per ton of ore crushed, it is not worth while to clean out the boxes very frequently; they had therefore been left undisturbed for nine months, at the end of which time all the amalgam was found to be crystallised. The mercury has been dissolved off by nitric acid, and the gold crystals remain. The smaller crystals are rather indefinite in shape, but amongst the larger ones are well-defined combinations of the octahedron, rhombic dodecahedron, and cube. Communicated by Mr. Bland.

Weights, &c. used in dealing with Gold.

1996. Fractional carat weights.

150 carats make 1 oz. troy; 1 carat ought, therefore, to weigh 3·20 grains, half a carat should weigh 1·60 grains, &c. These weights have been tested by R. Smith and found to be inaccurate. The $\frac{1}{2}$ carat weighs 1·58 grains instead of 1·60. The $\frac{1}{4}$ carat weighs ·80 grains, as it should; the $\frac{1}{8}$ carat weighs ·415 grains instead of ·4. The $\frac{1}{16}$ carat weighs ·185 instead of ·2; the $\frac{1}{32}$ carat weighs ·105 instead of ·1; and the $\frac{1}{64}$ carat weighs ·075 instead of ·05. These are also used for diamonds.

1997. Chinese commercial weights for gold and silver.

The largest is called the "Jael," and weighs about 580 grains; the middle size is called the "Mace," and weighs about 58 grains; the smallest, called the "Candareen," weighs about 5·8 grains. The Chinese, therefore, employ the decimal system in these weights. Each is marked with a distinctive Chinese word, doubtless their names. Communicated by C. Tookey when assayer to the Hong Kong Mint.

1998. Ashantee weight for gold called "Nymsu-acka-chĕrēē."

This is in the form of an ibex with extremely long horns. The value of the gold of this weight is 2*l.* 2*s.* 9*d.* Communicated by E. T. Macarthy in 1881.

1999. Ashantee weight for gold called "Bah."

It is in the form of a lizard with a curled tail. The value of the gold of this weight is 1*l.* 7*s.* Communicated by C. T. Macarthy in 1881.

2000. Ashantee weights for gold of unknown name and value.

These are flat brick-like weights. The larger has a complex, geometrical pattern on the upper side, and on the under side 16 small pits. The other has a key-pattern on the upper side, with eight wards, and on the under side two small pits. These patterns and pits probably indicate the value. Communicated by T. Macarthy in 1881. These doubtless are used by a different, more matter of fact tribe than the previous ones.

2001. Ashantee weight for gold called "Nyansah-por."

In the form of a knotted rope. The value of the gold of this weight is 3*l.* 12*s.* This weight and the two succeeding ones come from Achem, a country on the borders of Ashantee. The gold dust sold by them is valued at 3*l.* 12*s.* per oz., this weight being taken as equivalent to the ounce. It often assays to the value of 3*l.* 17*s.* per ounce. Communicated by E. T. Macarthy in 1881.

2002. Spoon used by the Ashantees and Fantees for weighing out the gold dust.

Communicated by E. T. Macarthy in 1881.

2003. Seeds of the *Abrus precatorius* used as weights for gold.

This seed is the "surkh" or "rati" used as the basis of Indian weights. It originally was reckoned at 1·75 of a grain, but now is estimated at 1·875 grains, so that 96 of them make a total of 180 grains. *See* Percy's Metallurgy, Silver and Gold, p. 375.

ALLOYS OF GOLD.

2004. Japanese obang.

This large oval coin, about 5·4 inches long and 3·2 inches broad, has the appearance of gold only on the surface. It bears the Mikado's private crest, and certain mint marks, and carries a value of 4*l.* 16*s.* The inner part is a white alloy, containing 36·75 per cent. of gold and 63·25 per cent. of silver, with a little copper. On heating the surface it loses its golden colour and becomes white, but the colour is restored again by hot dilute sulphuric acid. *See* Percy's Metallurgy, Silver and Gold, p. 402. Assayed by C. Tookey.

2005. Set of four alloys of silver and gold in different proportions, to show the effect upon the colour.

No. 1 has 50 per cent. of gold and 50 per cent. of silver. This has a light yellow colour, which, however, is partly due to tarnish. No. 2 has 60 per cent. of gold and 40 per cent. of silver. No. 3 has 66·6 per cent. of gold and 33·3 per cent. of silver. No. 4 has 75 per cent. of gold to 25 per cent. of silver. The colour gradually becomes deeper, and No. 1 is of light gold tint. Experiments by R. Smith.

2006. Alloy containing 95 per cent. of gold and 5 per cent. of aluminium.

Even this small per-centage of aluminium renders the gold much harder, and while the fresh surface is whiter, the tarnishing renders it a redder yellow, approaching to copper colour.

2007. Alloy of gold and magnesium.

The proportions of the two metals taken is not stated. The alloy was prepared in cryolite and fluor-spar. The rolled out fragment shows several cracks, as though the alloy was not very malleable.

2008. Alloy of gold, silver, and magnesium.

The proportions of the three metals taken is not stated. The alloy was fused in cryolite and fluor-spar. It is a yellowish-grey non-malleable material. When, however, the alloy was fused in carbonate of soda and carbon, a malleable button was obtained, which was rolled out and accompanies the alloy. The malleable alloy is probably due to the extraction of the magnesium by its oxidising out into the flux.

2009. Crystalline alloy of gold and bismuth.

In treating auriferous copper containing bismuth, a greyish-white alloy appears on the surface of the copper as the latter cools. This is found to consist of bismuth, holding in solution a crystalline alloy of bismuth and gold. The globules are rapidly attacked by nitric acid, leaving the alloy untouched. On melting this in a crucible under a flux the present specimen appeared on cooling. It consists of fine crystalline dust of a bronze-brown colour, with some long needles. It contains 68·22 per cent. of gold and 31·78 per cent. of bismuth. This and the two following were prepared and communicated by R. Pearce, of Denver, and described by him in the Transactions of the American Institute of Mining Engineers in 1885.

2010. Crystalline alloy of gold and silver.

This alloy was obtained by remelting some of the original alloy of gold and bismuth with a suitable quantity of silver to enter into combination with all the gold, allowing this to cool very slowly within a large red-hot crucible, and then treating the product with dilute, and afterwards with boiling nitric acid. The crystals left consist entirely of octahedra variously combined in groups. Some are large and disposed in pyramidal form, others are small and superposed in straight lines, forming an arborescent growth. In some the octahedra are cut off by parallel planes, making a plate divided into triangles. They contain 61·6 per cent. of gold and 35·8 per cent. of silver.

2011. Crystalline alloy of gold, silver, and copper.

This was obtained in a similar manner, by the addition of both silver and copper. If these metals are present in sufficient quantity, gold will not form an alloy with bismuth, but with them, and any excess of them is dissolved out by the dilute nitric acid which will not attack the alloy. This shows an arborescent crystallisation composed of smaller octahedra than the last, and contains 69·9 per cent. of gold, 27·96 per cent. of copper, and 2·1 per cent. of silver.

2012. Gold deposited on platinum, making a superficial alloy.

Prepared by Messrs. Johnson, Matthey, and Co., 1885. The other side of the platinum sheet shows its natural colour, for comparison.

2013. Complex alloy consisting principally of gold.

The analysis gives—

Gold	908·79
Silver	8·99
Copper	49·51
Antimony	14·52
Tin	13·49
Iron	4·10
	999·40

It has a dull grey appearance on the tarnished surface.

2014. Samples of alloys of gold and brass.

These circular discs, which are carved in patterns and engine-turned behind, were manufactured in Birmingham in 1850, and have been left to tarnish. They contain, in order from left to right, 8, 10, 12, 14, and 16 carats of gold. For purposes of commerce such articles are thinly coated with electro-deposited gold, to which they form the foundation.

GOLD AND ITS ALLOYS IN USE.

2015. Gilt pens. Manufactured by J. Gillott.

They are steel pens, with a coating of brass first, and then an electro-deposit of gold.

2016. Gold pens; inked, but not corroded.

2017. Fragments of a "half eagle" coin.

Analysed by R. Smith, and found to contain 90·15 per cent. of gold.

2018. Fragments of a 20 franc piece ?

Analysed by R. Smith, and found to contain 90 per cent. of gold.

2019. Argentiferous gold foil from Mycenæ.

This was brought by Dr. Schliemann from Mycenæ, and examined by Dr. Percy. It was one of the gold leaves found strewn in vast numbers about the bodies. It was much crumpled, and appears to have been lacquered; on heating, the foil becomes yellower. Boiling solution of caustic potash has a similar but weaker effect. 1·168 grains on cleaning with dilute hydrochloric acid lost 0·015 of a grain. The remaining 1·153 grains weight of cleaned metal has the following composition:—

Gold - - - - -	73·11
Silver - - - - -	23·37
Copper - - - -	2·22
Lead - - - - -	0·35
Iron - - - - -	0·24
	99·29

See Schliemann, Mycenæ and Tiryns, p. 368.

2020. Gold-plated electrotype, tarnished by age.

This was made by the firm of Elkington and Mason, in Birmingham, in 1845. It is an electrotype in copper of the Travelled Monkey. It was, when made, well gilded and tightly framed in papier-maché. It has since been taken out of its frame, after it had tarnished in it, but has never been exposed to acid or other chemical fumes. The principal tarnishing has encroached from the edges of the plate.

2021. False sovereigns of the weight and appearance of gold.

A large number of these were circulated about 1873–74. They consist of platinum and copper gilt. They have the weight of gold, and stand the test of acid. They have, however, a different ring by which they may be detected, and their rubbed edges have a white appearance.

2022. Mystery gold.

An artificial palate, made to resemble gold, to deceive pawnbrokers. It is composed of platinum to about one-eighth to one-tenth its weight, and the remainder of copper and tin. It is thin gilt. If rubbed with a file in the ordinary way, nitric acid will be resisted, unless laid on to the filed part for some time. It has also the weight of gold, and the ordinary distinctive tests fail. In former years, 1869–70, an enormous quantity of this material was manufactured in Paris for dentists, but being of the thickness of sovereigns, coins of it were stamped and gilt, and largely circulated.

2023. Ordinary spurious sovereign.

Analysed by Johnson and Matthey. Contains 89·9 per cent. of copper; 9·7 per cent. of zinc; and 0·4 per cent. of gold; in other words, it is gilt brass.

NOBLE METALS OTHER THAN GOLD.

Platinum.

2024. Platinum wire.

This wire, heated in an oxyhydrogen blow-pipe flame, gives a splendid green flame not like that of barium or copper. Rhodium has been said to give a green coloured flame. Communicated by Mr. Charles, late assistant at the Royal Artillery Institute.

2025. Platinum electro-deposited on silver.

By Messrs. Johnson, Matthey, and Co., 1885.

2026. Platinum electro-deposited on copper.

By Messrs. Johnson, Matthey, and Co., 1885. A thick plate of copper, with platinum on one side only.

2027. Spongy platinum.

Consisting of finely divided metallic platinum. If strongly heated it becomes denser, and will assume a metallic lustre on burnishing.

2028. Platinum and phosphorus.

Finely divided platinum is heated in vapour of phosphorus, and burns with evolution of light to platinum diphosphide—a bright metallic mass not attacked by hydrochloric acid, very easily dissolved by ammonia. *See* Roscoe and Schorlemmer's Chemistry, Vol. II., p. 421. Prepared by Dr. Percy in 1850.

2029. Silicon and platinum heated before the blow-pipe.

A few small metallic fragments.

2030. Platinum melted with silica.

A spongy mass, full of large cavities, and of white metallic appearance. The upper part is torn by the escaping gas, the small bubbles of which, passing outwards to the larger cavities, divide the intervening substance into a columnar form. Some of the cavities contain a white powder, used in the operation, which is not described.

PALLADIUM.

2031. Rolled palladium.

Prepared by Messrs. Johnson and Matthey, 1885. Palladium occurs in the Brazils and the Harz. It is separated by potassium iodide from its impure chloride. It is also obtained from the residues of platinum works.

2032. Palladium electro-deposited on copper.

By the late T. H. Henry, before 1855. A thin sheet of copper, coated on both sides with palladium.

2033. Alloy of palladium and hydrogenium.

This alloy was discovered by Graham, Master of the Mint; and these coins were produced by him there. They bear on the obverse the Queen's head, and on the reverse "Palladium-Hydrogenium, 1869," round the edge, and "Graham" in the centre. The alloy is formed by the absorption of nascent hydrogen by the metal. The amount of absorption is variable; the maximum reduced the alloy to a specific gravity of 11·06 as against 11·4; the substance, therefore, expands. At the time of its manufacture, the now tarnished coin was too large to pass through the accompanying ring; but by escape of the hydrogen by lapse of time it has become smaller, and now passes through it.

IRIDIUM.

2034. Iridium deposited from gold during fusion.

This is in the form of small metallic scales, forming a heavy coarse powder having a specific gravity of 22·38. It is deposited when native gold containing osmiridium (which this powder doubtless is, as iridium is never free from osmium without special processes) is remelted. This is the only way in which these metals can be separated from gold, as they are not attacked by any acids. *See* Crookes and Rohrig's Metallurgy, p. 660. Communicated by the Hon. C. W. Fremantle, Deputy Master of the Mint, London, 1876.

2035. Pure iridium.

Communicated by Johnson, Matthey, and Co., 1885. This is the spongy form of the metal. Impure iridium obtained from treating platinum is fused with 10 times its weight of lead. The lead is dissolved out by nitric acid, the residue is digested a long time with aqua regia, and the crystalline mass left unattacked is fused with potassium bisulphate to remove rhodium. To remove ruthenium this is melted with 10 parts of potassium hydrate and three parts of nitre in a gold crucible; a blue residue of potassium iridiate is obtained, which is washed with water, by which the ruthenium iridiate is taken into solution. The iridiate is repeatedly washed with water and acids and then dissolved in aqua regia, the solution evaporated to dryness, and the product dissolved in distilled water. The solution is filtered and poured slowly into a concentrated solution of soda containing sodium hyposulphite. This is subjected to a current of chlorine, which precipitates the blue iridium oxide, and this is reduced by a current of carbonic oxide and dioxide. It is then again heated to redness with potassium bisulphate, and washed with chlorine water to remove the traces of rhodium and gold. The pure iridium remains. *See* Matthey, "Chemical News," XXXIX., p. 175. It is of the greatest importance to obtain pure iridium to alloy with pure platinum to make the unalterable standards of length and weight. It should have a specific gravity of 22·39.

2036. Iridium obtained at the bottom of the crucible in melting Siberian gold at the Russian Mint.

This is the massive form of osmiridium. It contains scattered particles of a transparent substance, probably sand. Communicated by Sir C. Wheatstone.

2037. Slag containing iridium.

A spongy mass produced by fusion, from Mr. Phillips' collection, and labelled by him as containing iridium.

OSMIUM.

2038. Native alloy of osmium and iridium.

In the form of small flat scales of tin-white colour and metallic lustre, among which the hexagonal form is occasionally observable. Locality not stated. This alloy contains from 53 to 58 per cent. of iridium, and 31 to 43 per cent. of osmium, being commonly contaminated with rhodium and ruthenium.

2039. Osmium compressed while strongly heated.

Communicated by Mr. Sellon, of Johnson, Matthey, and Co., 1871. It is obtained from the native osmiridium in the process of preparing ruthenium. The solution of volatile tetroxide is precipitated with ammonia and ammonium sulphide, the precipitate mixed with salt and heated in a slow current of chlorine. The mass yields on lixiviation an osmichloride of sodium, from which ammonium oxychloride is thrown down by sal ammoniac. When this is heated in a covered crucible, spongy osmium is obtained. It has never been fused, but when strongly heated it compresses into a compact metallic body, the maximum specific gravity being 22·477. This substance, therefore, is the heaviest body known.

RUTHENIUM.

2040. Alloy of ruthenium and tin.

From the French Department, International Exhibition, 1862. Prepared by Deville and Debray. Ruthenium is obtained from the alloy of osmiridium by fusing with zinc, the regulus is treated with hydrochloric acid, and one part of the finely divided residue is mixed with three parts of barium dioxide and one part of barium nitrate, and the mixture heated for two hours to a bright red heat. The cold mass is powdered finely and thrown into hydrochloric acid; when the action is over one part of nitric and two of sulphuric acid are added, the barium sulphate allowed to deposit, and the clear liquid is separated and distilled to one quarter its bulk, to which is added two parts of sal ammoniac and a little nitric acid, and the whole is dried in a water bath. This is washed by water with sal ammoniac, and the residue is ignited, and the remainder fused for two hours in a silver basin with two parts of nitre and one of caustic potash. The fused mass is dissolved in water, forming an orange-red solution of rutheniate of potassium. This is treated with nitric acid till the yellow colour disappears, when ruthenium oxide separates, which is reduced in a graphite crucible. The ruthenium thus obtained is heated to redness in a graphite crucible with 10 to 15 times its weight of tin, and when cool the excess of tin is dissolved out by hydrochloric acid. The alloy then remains in magnificent cubic crystals of brilliant lustre, like those produced by melted bismuth.

RHODIUM.

2041. Spongy rhodium.

This is obtained from the liquors from which platinum salts have been precipitated. The metals in solution are precipitated by metallic iron, and the precipitate fused with one part of lead and two parts of litharge. A regulus is thus obtained from which the other metals are dissolved out by dilute nitric acid. The metallic powder left is mixed with five parts of barium dioxide and heated to redness for two hours, the solid mass lixiviated with water, and the osmium tetroxide driven off by aqua regia, and the barium oxide precipitated by sulphuric acid. The filtrate is evaporated at 100° with an excess of sal ammoniac, and afterwards with nitric acid, and the residue heated with three to four parts of sulphur. It is then rapidly boiled out by sulphuric acid and aqua regia, and nearly pure rhodium is thus obtained.

2042. A red powder, labelled " Metallic " rhodium.

CADMIUM.

2043. Cadmium fume mixed with zinc fume.

From the Spelter Works, Mines Royal, South Wales. This is the crude material from which metallic cadmium is obtained. It is given off with the brown smoke at the commencement of the distillation of zinc, and consists of the mixed oxides and carbonates of cadmium and zinc.

2044. Bar of metallic cadmium.

The cadmiferous fumes are heated to 360° C., which only fuses zinc, but volatilises cadmium, and on cooling it is deposited as a brown oxide. This is reduced by means of charcoal in a small cylindrical cast-iron retort, furnished with a conical iron plate adapter, closed with a pierced wooden plug. The cadmium collected in the iron adapter is remelted and cast into this long cylindrical bar. *See* Crookes and Rohrig's Metallurgy, Part I., p. 468.

2045. Metallic cadmium made in Germany.

This is the commercial unpurified material, obtained from zinc, in Germany, where it was discovered.

2046. Bar of metallic cadmium; purified.

Prepared by Johnson, Matthey, and Co.

2047. Ingots of remelted cadmium, showing the roughness.

2048. Hydroxide of cadmium.

A white powder obtained by precipitating a soluble salt of cadmium by caustic potash.

2049. Sulphide of cadmium.

A bright yellow powder, obtained by precipitating a soluble salt of cadmium by sulphuretted hydrogen.

TIN.

Laboratory Experiments.

2050. Aurum musivum.

Bisulphide of tin prepared by heating 2 parts of tin, 1 part of mercury, 1 part of sal ammoniac, and 1¼ parts of sulphur.

2051. Bisulphide of tin.

Prepared by heating 5 parts of sulphide of tin with 8 parts of corrosive sublimate.

2052. Bisulphide of tin coated with sulphide of tin.

Communicated by C. Button.

2053. Crystalline sulphide of tin.

This has a well-marked crystalline cleavage, and a bluish-white metallic lustre. It is formed by projecting sulphur upon melted tin and stirring with an iron rod. Experiment by W. Baker, 1854.

2054. Sulphide of tin.

Prepared by the same operation as that producing No. **2050**, at a different stage of the process. It is from this that No. **2051** was prepared.

2055. Oxide of tin, fused into a glassy form.

Opaque-white, and banded.

2056. Result of fusing one equivalent of sulphide of antimony with three equivalents of tin.

500 grains of sulphide of antimony were mixed with 498 grains of pulverised tin, and placed in a pot with a luted cover, and kept at a bright red heat for 10 minutes, and broken open when cool. It is metallic and crystalline, with a platy cleavage like that of sulphide of tin. Experiment by W. Baker, 1854.

2057. Result of fusing tin stone and hæmatite together.

75 grains of tin oxide prepared by treating tin with nitric acid were heated to a white heat, with 160 grains of ferric oxide which had been

previously heated to redness. The result has the aspect of a regulus, which is more or less porous. Experiment by Dr. Percy.

2058. Result of fusing together hæmatite, limestone, and tin stone.

80 grains of ferric oxide, 50 grains of calcium carbonate, and 75 grains of tin oxide were fused together. The result is a regulus-like mass, not very bright, and with a few cavities. Experiment by R. Smith.

2059. Button of tin obtained by treating tin slag.

800 grains of slag, 15 grains of borax, and 300 grains of carbon were fused together. The resulting metal button weighs 34·9 per cent. of the original slag. Experiment by R. Smith.

2060. Results of four experiments on heating iron pyrites with cassiterite.

All the mixtures were heated for three quarters of an hour in French pots, placed within another crucible, and filled up to exclude air. In No. 1, 240 grains of iron pyrites, and 148 of tin ore were mixed. The result is an irregular mass with a brilliant metallic appearance in parts. In No. 2, 240 grains of iron pyrites, 148 grains of tin ore, and 36 grains of sand were taken. The result is very scoriaceous and frothy, and less metallic. In No. 3, 240 grains of iron pyrites, 148 grains of tin ore, 36 grains of sand, and 12 grains of charcoal were taken. The result is a uniform, compact, crystalline, metallic substance. In No. 4, 120 grains of iron pyrites, 74 grains of tin ore, 46 grains of sand, 80 grains of hæmatite, and 12 grains of charcoal were taken. The result is very frothy, and scarcely metallic. Experiments by R. Smith.

2061. Result of heating copper pyrites with cassiterite.

368 grains of copper pyrites were mixed with 148 grains of tin ore, and heated strongly for three quarters of an hour. The result was a regulus weighing 412 grains, showing a loss of 104 grains. Some needle-shaped crystals of stannic oxide have been formed in the cavities. Experiment by R. Smith.

ORES OF TIN AND THEIR PREPARATION FOR SMELTING.

2062. Mine tin.

Prepared from the massive tin stone, or binoxide of tin by simple crushing between rollers, and not using stamps. From the Trevaskis Mine, Cornwall. Contains about 75 per cent. of tin. Communicated by Mr. Wellington.

2063. Black tin as dressed by the old process (fluran).

From Drake Wall's Tin Mines, Cornwall. The ore is called black tin after it has been calcined, for the purpose of driving off any sulphur or arsenic present, and reducing the impurities to oxides lighter than the tin ore, which is unaffected. These are then washed away, and this "black tin" is left.

2064. Black tin as dressed by the old process.

This has been "jigged" from massive ore, and prepared by roasting as above. From Drake Wall's Tin Mine, Cornwall.

2065. Black tin dressed by R. Oxland's process.

This process consists in the employment of a revolving calciner, in the form of a long cylinder lined with fire-brick, and placed in an inclined position. The arsenic is thus removed, and the ore is washed and jigged, and contains from 60 to 70 per cent. of tin. Drake Wall's Tin Mine.

2066. Mixture of ore for common tin.

This has been ground into powder. From the Chyandour Smelting Works, Penzance.

2067. Average sample of refined tin ore.

This has been ground to powder, and separated by washing. Chyandour Smelting Works, Penzance.

2068. Residual deposits thrown out after grinding and washing the tin ore.

These particles are much lighter than the tin ore, and are thus separated. From the Chyandour Smelting Works, Penzance.

2069. Tin ore in stage No. 1 of the dressing and preparing.

Taken from the stamps grate on the side on which the ore is most contaminated with wolfram. From East Pool Tin Works, Cornwall.,

2070. Tin ore in stage No. 2.

This has been dressed and passed through two round buddles, and is now ready for calcining. From East Pool Tin Works, Cornwall.

2071. Tin ore in stage No. 3.

This is the same as No. 2 after it has been calcined to drive off the sulphur and arsenic from the associated pyrites. From East Pool Tin Works.

2072. Tin ore in stage No. 4.

This is dressed ready for roasting with salt. It has been washed and the heavier parts consisting of the tin ore separated. From East Pool Tin Works.

In the second roasting 12 lbs. of salt is added to each cwt. of the ore for the purpose of forming tungstate of soda with the wolfram which is present and cannot be removed by washing.

In the series there is a 5th stage, of which a sample is wanting. It represents the tin and wolfram after it has been roasted for six or seven hours. It is then sent to the stamps and stamped with quartz for the purpose of breaking up the coherence of the mass.

2073. Tin ore in stage No. 6.

It has now been submitted to the stamps and washed, whereby the tungstate of soda is washed away, though the tungsten is not entirely removed by this process, and the whole is still subjected to a further process of dressing, after which it is ready (as stage No. 7) for the market. East Pool Tin Works, 1868.

2074. Sample of sand containing tin stone from Brittany.

2075. Tin ore obtained from the sand (**2074**) by washing.

A fragment of gold is also contained in the sample. Communicated by Mr. Grant.

2076. A cupreous tin ore obtained from copper works.

It is called in the copper works "burnt leavings." It is calcined and then washed, and the heavier tin oxide is thus separated from it. From Hafod Copper Works, South Wales, 1848.

2077. Tin ore from Salangore.

Massive crystalline tin stone imbedded in a quartz vein. It is found in rivers as stream tin. It is from this part of the world, the East Indies, that the purest tin is obtained. Communicated by Mr. Barker.

2078. Tin ore from Tasmania.

From the N.E. crop of a lode in Mount Bischoff in the N.W. of Tasmania. It is a massive vein, associated with much brown limonite. Communicated by Mr. C. Gould, 1874.

2079. Blitong tin ore, Australia.

This is tin oxide irregularly diffused through a mass of ferric oxide, which is itself part of a vein. In the larger specimen only a string of tin stone is visible; in the smaller the whole mass is impregnated with it.

2080. Iron pyrites said to contain 3 per cent. of tin.

Communicated by F. O. Ward, 1867.

2081. Massive tin stone from Australia.

This was purchased in 1853 in the sale of an Australian mineral dealer, notorious in gold-hunting circles. It has been rubbed on the surface with gold. It was nearly 20 years after this before tin was worked in Australia.

2082. Tin stone, locality unknown.

2083. Tin ore from which the gold has been extracted.

By Messrs. Johnson and Matthey. No gold found on assay by R. Smith.

2084. Coarse-grain tin ore from Parrit, Tenggah, Salangore.

2085. Fine-grain tin ore from Boonoes, Salangore.

2086. Black tin after calcination with sulphate of soda.

Sulphate of soda is used in Oxland's process for removing the wolfram, or tungstate of iron and manganese. By an alternately oxidising and reducing action the tungsten unites with the soda and leaves the oxides behind on washing. This sample is in the unwashed state. From Drake Wall's Tin Mine.

2087. Tungstate of lime formed in Oxland's process.

The tungstate of soda washed from the calcined ore is precipitated by common salt, and an insoluble tungstate of lime obtained. Drake Wall's Tin Mines.

2088. Tungstate of lead formed in Oxland's process.

The tungstate of soda is also precipitated by a soluble salt of lead yielding a white precipitate of tungstate of lead. Drake Wall's Tin Mines.

TIN SMELTING.

2089. Tin slag, glassy form.

The washed and purified tin stone is simply melted with anthracite together with some flux, to form a slag with the siliceous impurities of the ore; according to the flux so the slag. In this case a ferruginous flux has probably been used. Remains of the quartz are scattered over the surface.

2090. Tin slag, compact form.

Contains fragments of coke upon its surface, but no quartz or visible tin.

2091. Slag from tin smelting at Gyenap.

Scoriaceous towards the top, and with fragments of the unmelted flux and blebs of tin.

2092. Penrose's tin slag.

Said not to contain more than 3½ per cent. of tin. A brown semi-transparent glass. Landore Tin Works, 1859.

2093. Glassy tin slag.

From Chyandour Tin Works, Penzance, 1859. This is largely contaminated on the surface with mechanically enclosed tin. It was tapped from the smelting furnace at the same time as the metal, and is the richest kind of slag produced.

2094. Furnace bottom at tin works.

This is the remnant left in the smelting furnace after the slag has been run off the top, and the metal off the lower part. It consists of scoria, dross, and particles of metallic tin, and has to be remelted. From the Chyandour Smelting Works, Penzance, 1858.

2095. Crystalline metallic substance found between the bricks of an old tin smelting furnace.

The tin smelting furnaces at the Huel Vor Mine were continued for about 20 years and then taken down. The whole of the inner surface was much injured and broken down, and cavities of all sizes, sometimes including the divisions of several bricks, were found. All these cavities up to those of 10 in. by 7 in. were filled with this metallic material. The still larger cavities were more or less lined with it. It was more abundant where there was lime than where there were only bricks. The substance consists of thin plates crossing each other at all angles.

Refining of Tin.

2096. "Hard head."

From Chyandour Smelting Works, Cornwall. This is the remainder of the ingots of impure tin left on the refining hearth after all the purer tin has been liquated out into the kettle. It contains all the foreign metals which were associated with the tin. It is very hard, semi-crystalline and fibrous.

2097. "Hard head" calcined at first *per se,* afterwards with the original rock, and lastly *per se,* until it ceased to give off fumes.

2098. "Hard head," powdered.

2099. "Hard head" fused with sulphur.

Experiment by Dr. Percy, 1858. Hard head being produced from roasted ores, contains little or no sulphur, and on fusing with sulphur the metals become sulphides. This is a compact, porous, regulus-like mass.

2100. "Hard head" heated with lime after calcination.

Experiment by Dr. Percy, 1858. A compact mass of sub-metallic appearance, and filled with small holes, is produced.

2101. "Hard head."

A massive yellowish sample with crystalline cleavage, with portions of the hearth floor adherent.

2102. Skimmings from the tin pot.

From Bolitho's Tin Works, Penzance, 1858. Consisting of fragments of metallic tin, with the oxide dust produced in the air.

2103. "Hard head" not properly removed from Mexican tin.

Out of 60 lbs. of metal sold as tin, 3 lbs. of this metallic impurity, or hard head, was extracted on remelting.

2104. Crystals found on some of the hard head at the Redruth Smelting Works.

Communicated by L. Young, 1874. This is the same crystalline metallic substance in their crossing plates as in No. **2095.**

2105. Dross skimmed off the kettle of common tin.

From Chyandour Smelting Works, Penzance, 1858. It is skimmed from the surface of the melted metal, after it has run out of the hearth into the kettle, while it is being refined. The metal is laded out at the same time that it flows in from the furnace; but in refined tin the metal is not laded out during the time of running from the furnace. It is kept in the kettle five or six hours. Analysed by C. Tookey in 1881.

Tin - - - - - -	93·73
Iron - - - - - -	3·89
Arsenic - - - - -	1·19

Copper - - - -	0·31
Cobalt - - - -	0·10
Sulphur - - - -	0·62
	99·84

This shows that it is metallic tin contaminated with "hard head."

2106. Residual product from refining tin in South America.

Hard head mixed with tin. Communicated by Mr. Darker.

2107. Crystals formed on the surface of tin-slag.

From the Chyandour Tin Works, Penzance. Communicated by A. K. Barnett. This is the same brilliant tin-white, platy, metallic substance as the last. In these specimens the crystalline form is clearly seen. It consists of plates parallel to the basal plane of a tetragonal prism. As tin is the only metal which crystallises in the tetragonal system, it appears that these crystals are essentially metallic tin, though contaminated with impurities.

2108. Crystals on the surface of tin-slag and in cavities.

This is the same metallic tin as No. **2107.** The crystals are more delicate, and the mass has been formed in the cavities between the bricks in the bottom of the smelting furnaces, and found when they were broken up in 1879. Communicated by A. K. Barnett. From the Chyandour Tin Works.

2109. Portion of the furnace bottom showing the position of the above crystals.

The bricks are all fractured and filled with metallic substance. The intervals between have an exterior layer of greyish metal, and the inner face has these tin crystals growing from the sides. They must have formed during the contraction in cooling.

2110. Product of the first process of tin refining.

From the Mellanear Tin Smelting Works, Hayle, Cornwall. Communicated by G. B. Pearce. This is not the final hard head, containing no tin, but an intermediate product, with tin mechanically mixed. It is covered by conical protuberances, apparently perforated at the top, and divided into segments, as though metal had oozed out of the summit and divided in various streams.

2111. Crystalline slag from tin smelting at Redruth.

Arborescent crystals in thin plates, which are occasionally iridescent on the surface. It has an entirely metallic aspect, and is doubtless produced in the refining process.

2112. Crystallised hard head.

From Chyandour Smelting Works, 1880. These are dull-coloured, flat crossing plates, which have formed on the surface. They have no definite crystalline form, and their dulness is due to surface oxidation, &c., the interior fracture being metallic and of the colour of hard head.

2113. Mosaic gold on the surface of "hard head."

From the Chyandour Smelting Works, Penzance, 1881. The grey mass is sub-metallic, and finely porous. The golden looking deposit has formed in the cracks, and doubtless consists of sulphide of tin, which has this colour. *See* No. **2051,** &c. It is probably produced by the action of sulphur, in combination with the associated metals, on the oxide of tin.

VARIOUS FORMS OF THE METAL.

2114. Crystallised metal obtained by the remelting of tin canisters.

The sweep from the manufacture of hexagonal powder canisters is remelted with the old canisters, which are made of block tin. The crystals are long tetragonal prisms, and are doubtless crystalline tin metal. From Messrs. Shears.

2115. Tin rendered "crystalline" by exposure to intense cold.

These so-called crystals are really columnar fragments, which may follow more or less the crystalline form the metal might take; but they have no regular shape, nor any crystal surface. The tin was exposed to intense cold in St. Petersburg; during the winter it was found broken up into these particles; a result experimentally repeated by Fritsche. *See* Berichte Deutsch. Chem. Ges., II., p. 112. Communicated by W. C. Roberts.

2116. Samples of crystals of tin.

Separated from the tin, of which an ingot accompanies them (No. **2139**).

2117. Crystallised tin.

Communicated by Professor W. H. Miller. In this specimen are crystal combinations of the tetragonal pyramid, tetragonal prism, and basal planes.

2118. Granulated tin, in small particles.

2119. Metallic tin, as it ran into the "float."

Chyandour Smelting Works, 1858. Common tin.

2120. Metallic tin, as it ran into the "kettle.

Chyandour Smelting Works. One of the three products of the refining process, 1858.

2121. Refined metallic tin.

From Chyandour Smelting Works, 1858.

2122. Inferior tin.

From the Wheal Owles Mines. Smelted at Chyandour, 1858.

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2123. Common tin, from Chyandour Works.

This is the refined common metal, being an assay taken out of the kettle when refining the metal from the common tin ore mixtures, accompanied by an assay of the primary regulus of the mixture.

2124. Refined tin, from Chyandour Works.

This is the refined metal, being an assay taken out of the kettle when refining the metal from the refined tin ore mixture, accompanied by an assay of the primary regulus of the mixture.

2125. Tin as laded from the kettle for the block.

One of the three products of refining common tin at Chyandour Works.

2126. Tin used for experiments on crystallising tin by Pattinson's process for lead.

Experiments by R. Smith. No. 1.
No. 2 is wanting.

2127. Sample of the residuum after the crystals were separated, in these experiments.

2128. Series of ingots of tin used in experiments for purifying it by Pattinson's process for lead.

Three ingots marked 3 C, 4 C, 5 C, apparently from their lustre consisting of common tin : and three ingots of the same size marked 1 R, 2 R, 3 R, doubtless refined, and a smaller one marked 4 R. There is also a sample marked "original specimen Bolitho Penzance." The actual experiments are not recorded.

2129. Grain tin.

Showing roughly the prismatic crystallisation of the metal.

2130. Tin foil.

2131. Tin melted in a crucible.

2132. Sample of tin produced by assay from ore obtained at Wheal Margaret, Cornwall, 1858.

Probably contains copper.

2133. Best refined tin.

Produced in 1858 by Messrs. Bolitho, Chyandour Smelting House. Adapted to the manufacture of tin plate. Refined tin was then about 2½ per cent. more valuable than common tin.

2134. Sample of tin produced by assay, from ore obtained at Wheal Vor, Cornwall.

Supposed to contain copper, and possibly bismuth and lead.

2135. Sample of tin produced by assay, from ore obtained at Wheal Owles.

Believed to contain iron. Penzance, 1858.

2136. Second quality of tin.

As produced at the Chyandour Works in 1858.

2137. Electro-deposited tin.

Showing a brilliant square pyramid, banded parallel to its basal edges. A microscopic slide. Communicated by Mr. Makin, 1872.

2138. Electro-deposited tin.

In an arborescent form. Communicated as above by Mr. Makin.

2139. Ingots obtained from melting down medicine case.

Melted at the Houses of Parliament from cases of "Lloyd's Euxesis." It has been tested and found to consist substantially of tin.

2140. White bronze, or tin reduced to a fine powder by lamination, trituration, and lævigation.

Manufactured by Lane, 1847.

2141. Sample of tin produced by assay from Australian tin ore.

From the Chyandour Smelting Works, Penzance, 1858.

2142. Sample of tin remelted from Banca tin.

The Banca tin is the purest form, it is from an island in the East Indies.

2143. Peruvian tin smelted in Peru.

A very impure ingot, the surface is all covered with dendritic crystallisation, apparently belonging to the cubic system.

2144. Sample of tin produced by assay, from large pits of tin ore obtained in Brittani (*sic*).

2145. Tin from Banca in the East Indies.

Remelted and purified at Shanghai, and cast in an ornamental pyramidal ingot with a Chinese symbol on it.

2146. Tin from Borneo.

A wedge-shaped mass. Marked "Rajah Sarawak, S. and I. 29." Communicated by Mr. Budd.

2147. Bar of tin from the first ton of Colonial tin.

Marked G. T. and Co., April 1853.

ALLOYS OF TIN.

2148. Alloy of tin and copper.

Consists of 20 parts by weight of tin and one part by weight of copper. This is included among the alloys called pewter, which may contain copper up to 20 per cent. or down to 5 per cent.

2149. Alloy of four parts of tin with six parts of copper.

It has a dull white colour, but is very compact and finely granular. Supplied from Berlin.

2150. Alloy containing one part of tin, two parts of nickel, and four parts of copper.

Total weight 1,375 grains, prepared in 1845.

2151. Britannia metal in rolls.

This usually contains from 80 to 85 per cent. of tin, from 10 to 16 per cent. of antimony, and 2 to 3 per cent. of zinc.

2152. Britannia metal.

From Mr. Sturges, Birmingham. Contains about 80 per cent. of tin and 15 per cent. of antimony.

2153. " Bearing metal."

This is used for bushes in steam engines, as it wears against iron. The usual composition of such material, known as " white " or " anti-friction " metal, is 85 per cent. of tin, 10 per cent. of antimony, and 5 per cent. of copper. Communicated by Mr. May.

2154. Alloy of 94 parts of tin with six parts of arsenic.

The ingot has a very crystalline surface, with acicular, and platy crystals, and has a still more crystalline fracture.

2155. Alloy of tin containing 10 per cent. of arsenic.

Communicated by D. Watson, Broughton Copper Works, 1882. It has a highly crystalline surface, of vertical plates. The fracture is of a brilliant white colour, and very crystalline in broad plates.

2156. Alloy of 90 parts of tin with 10 parts of aluminiun.

The result is a non-malleable alloy, irregular in its fracture, and dividing into thin plates, which are brittle on hammering out.

2157. Alloy of tin containing 10 per cent. of magnesium.

It is a dark-coloured granular mass, very brittle and sub-crystalline. It has scarcely a metallic appearance.

2158. Alloy containing four equivalents of iron to one of tin.

Made by fusing 1,120 grains of sheet iron with 590 grains of tin, at a white heat. Experiment by R. Smith. A bluish-white, granular, sub-crystalline mass of considerable hardness.

2159. Alloy of tin containing 5 per cent. of phosphorus.

To be used in the manufacture of phosphor bronze. A white crystalline mass, of a highly metallic lustre. Communicated by H. Simon, 1877.

2160. Alloy of tin and phosphorus.

Made by Messrs. Billington and Newton, Longport, Staffordshire, 1881. It contains 3·3 per cent. of phosphorus. It is bought by copper smelters at Manchester for making phosphor bronze. Its fracture is largely and broadly crystalline. It is said to be produced under pressure. Communicated by D. Watson.

2161. Babbitt's patent metal.

This contains 10 parts by weight of tin, one part of regulus of antimony, and one part of copper. The accessory ingredients may be varied in proportion, but the essential feature is the larger proportion of tin. It is a hard and tough material, with a pretty uniform but coarsely granular fracture.

2162. Tin alloyed with tungsten.

This is the produce of the Drakewalls Tin Mine. The tin in Cornwall being largely contaminated with wolfram, the tin derived from it, unless refined, is really an alloy of tin and tungsten. Its presence renders the tin darker in colour and more difficult to fuse. Communicated by D. Matthews.

2163. Solders of various descriptions.

1, Spelter solder, of a yellow colour for brass work. 2. Silver solder, a white alloy. 3. Pewter solder.

USES OF TIN.

2164. Enamel containing 6 per cent. of oxide of tin.

2165. Early specimen of ornamental tin plate.

Procured from Messrs. Leach, Flower, and Co.'s Works, Neath, before the process was introduced into the market. The vehicle of the pigment is a kind of varnish; the plate when painted over is heated pretty strongly in an oven.

DECAY OF TIN.

2166. Scale from the surface of "Jews House" tin, Tremenhack, Penzance.

The metal seems to have been run in ancient time into a shallow pit, and the upper and lower surfaces are now encrusted for the thickness of an eighth or a quarter of an inch with a substance of non-metallic appearance. This has been analysed by R. Smith, and found to consist chiefly of oxide of tin, a small quantity of oxide of iron and water, and a scarcely perceptible trace of chlorine. The latter is doubtless derived from the saline spray which saturates the air of the Cornish coasts. Communicated by W. J. Henwood, 1871.

2167. Flaws in tin plates.

After tinning, irregular spots, such as are seen in this specimen, make their appearance. It is supposed that in the process of tinning, after the iron plate has been dipped in the acid, some of this "pickling liquor" remains in the cracks and crevices unperceived, and eats its way into the tin at a later period.

ANTIMONY.

EXPERIMENTS.

2168. Jamesonite, fused and cooled slowly.

Experiment by R. Smith. Jamesonite contains about 33 per cent. of antimony in combination with sulphur, in addition to ordinary metallic sulphides. These masses show an eminently fibrous structure.

2169. Massive sulphide of arsenic, produced by fusing the precipitated sulphide.

Experiment by W. Baker. It has a fibrous structure, somewhat similar to the more massive varieties of native stibnite.

2170. Antimony reduced from its sulphide by fusing with charcoal.

Experiment by W. Baker.

2171. Sulphide of antimony reduced by heating one equivalent of it with three equivalents of iron.

One equivalent of antimony and three of ferrous sulphide are produced. Experiment by W. Baker.

ORES OF ANTIMONY.

2172. Native antimony from Borneo, pulverised.

2173. Stibnite, or sulphide of antimony.

A columnar mass, locality unknown.

2174. Hungarian crude black antimony.

This is derived from the native ore by simple fusion to separate the gangue. Analysed by J. Ward. Contains 70·28 per cent. of the metal, and is therefore nearly pure sulphide. Communicated by R. G. Schwarz.

2175. Oxide of antimony.

Probably produced by the oxidation of the sulphide, and therefore senarmonite. From New South Wales. Communicated by Messrs. Johnson and Matthey, 1871.

2176. Valentinite from South Ham, near Quebec.

An oxide of antimony, crystallising in radiating tufts belonging to the rhombic system. This sample has been analysed by R. Smith, and yields—

Antimony oxide - - -	89·95
Antimony sulphide - - -	6·52
Iron sulphide - - - -	0·09
Gangue (Silica, &c.) - - -	3·29
	99·85

This is equivalent to 79·83 per cent. of metallic antimony.

2177. Mixed oxides of antimony obtained by roasting native antimony sulphide.

The product has been powdered. Experiment by W. Baker, 1854.

EXTRACTION OF ANTIMONY.

2178. Antimony ore and gangue from Borneo, pulverised.

The intermediate product obtained in washing the native sulphide ore.

2179. The fused product of No. **2178**, still containing the antimony sulphide mixed with the gangue.

2180. Pure sulphide of antimony ore from Borneo.

Separated from the gangue by washing. A large amount floated off in the process and was only deposited after standing, showing that this method of separating the ore would not avail commercially. Experiment by R. Smith.

2181. Residual gangue after liquating the powdered and washed antimony ore. No. **2180.**

The antimony still retained has sweated out on the surface on cooling.

2182. The antimony derived from No. **2180**, after the gangue is removed.

2183. Poor antimony ore from Borneo.

Used in extracting the pure antimony sulphide as below. This is a sulphide ore mixed with a considerable quantity of vein stuff.

2184. Residual gangue after the antimony is liquated out.

2185. The antimony which has been liquated out of the ore.

Forming the ordinary crude antimony in needle-shaped crystals.

2186. Rich antimony ore from Borneo.

This is also the sulphide, much more free from gangue.

2187. The residual gangue after the antimony has been liquated out.

2188. The regulus or sulphide of antimony which has been liquated out of the ore, and subsequently fused in a crucible.

The process is simply heating the ore in a cylinder or in a furnace with an outlet below, out of which the fused ore runs into a receptacle.

2189. Product from smelting antimony ore in Borneo.

Shows various crystalline products in the form of hexagonal plates, fibres and transparent octahedra. Communicated by Mr. Russell.

2190. " Metal " product from smelting Borneo antimony ore, by Messrs. Hallett.

This is the residue after the antimony has been extracted. It contains some globules of metal here and there.

2191. The flux used in smelting the antimony ore, by Messrs. Hallett.

METALLIC ANTIMONY IN VARIOUS FORMS.

2192. Antimony obtained by smelting the ore from Borneo, by Messrs. Hallett.

A very irregularly crystalline mass ; not very compact.

2193. Common commercial antimony.

In large compact crystals radiating from the side.

2194. Antimony from Leghorn.

A pure white sample of broadly crystalline fracture.

2195. Antimony obtained by reducing the native oxide by charcoal.

Experiment by R. Smith. The antimony thus obtained is in small globules, producing a dark grey powder in bulk.

2196. Crystals of antimony.

There are a number of cubes built up upon one another, yet remaining distinct, so as to form a mass like bismuth. There is no tendency to radiation here seen.

2197. Crystals of antimony.

Produced as a furnace product, in the smelting of ores containing antimony. It consists of similar aggregated cubes, and hopper-shaped crystals, for the most part coated over with a dark grey powder, which appears to be the metal in a more pulverulent form. Communicated by Josiah Cooke.

2198. Metallic antimony containing arsenic.

Communicated by W. W. Smyth. It has a brilliant white, broad, crystalline, flat fracture.

2199. Antimony electro-deposited on a brass plate.

Communicated by G. Gore, 1855. It has been deposited from a solution consisting of 1 oz. by measure of hydrochloric acid, ¾ oz. of water, and 500 grains of tartar emetic. The anode was of commercial antimony, and of about the same size as the cathode. The process occupied about three days with four Grove's cells in series. This has not been found to be explosive. It consists of botryoidal masses of brassy lustre and fracture, coated with darker metal. The antimony seems therefore to have alloyed itself with the brass.

2200. Antimony obtained from the solution, from which explosive antimony was obtained.

It is now excessively brittle, but not explosive. It has been deposited by electrolysis from a solution of tartar-emetic and ordinary terchloride of antimony, then washed in dilute hydrochloric acid, and distilled water, and dried. It would appear that the chlorine has escaped. Communicated by G. Gore (the discoverer of explosive antimony), 1855.

2201. The above antimony powdered under ice and salt, and dried over sulphuric acid for several months.

It is now a brown metallic powder.

ALLOYS OF ANTIMONY.

2202. Alloy composed of equal parts of antimony and copper.

It has a peculiar purple tinge and a crystalline fracture, and is commonly known as "Regulus of Venus."

2203. Alloy containing 50 per cent. of antimony and 50 per cent. of tin.

A bar made by Mr. E. Matthey, 1883. The fracture is very finely granular, and the bar is very brittle. This kind of alloy is said to be the only one suitable for use in dry gas meters.

2204. Alloy composed of antimony and phosphorus.

Experimentally made in a crucible under salt. It is brilliant white, and excessively brittle. It has a flaky fracture, irregularly disposed, the surface of the flakes being spotted.

OTHER SPECIAL COMPOUNDS OF ANTIMONY.

2205. "Crocus of antimony."

Produced by fusing together 1 cwt. of black sulphide of antimony and 12 lbs. of nitrate of potash. Communicated by W. Ratcliffe, 1879. A reddish, slightly porous, regulus-like mass, containing oxysulphide of antimony. One of the earliest preparations from the metal (15th century).

2206. "Kermes mineral."

Prepared by W. Baker. This is one of the ancient (15th century) preparations of antimony, and supplied one of its earliest uses for medicinal purposes. It is an amorphous form of the native sulphide, and is produced from it by fusing it with carbonate of soda, and precipitating by sulphuric acid. It is now used for colouring and vulcanising indiarubber.

2207. "Glass of antimony."

Prepared by W. Baker, by fusing the oxidised sulphide, with a small quantity of the same unoxidised. It forms a large dark red, almost opaque glass, used for staining window glass. It has been known and used from the fifteenth century.

2208. "Glass of antimony."

Also called "Liver of Antimony." Prepared by W. Baker by fusing together oxide of antimony, prepared by roasting the sulphide, with half its weight of sulphide of antimony unroasted. It is dark brown and quite opaque.

2209. "Crocus of antimony."

Prepared by W. Baker. It is dark brown and opaque, not to be distinguished from the darker glass of antimony.

2210. Sulphide of antimony fused with carbonate of soda.

Five parts of the first with three of the second have been fused together for the production of kermes mineral, by precipitating the solution of this. Experiment by W. Baker, 1854.

2211. Antimoniate of potash.

Prepared by R. Smith. This was also known in the fifteenth century as "antimonium diaphoreticum." It has been here prepared by heating 450 grains of the native oxide of antimony (sample shown) with 50 grains of nitre, producing a yellow powder. This has been boiled four times in water, producing a lighter yellow powder, the preparation in question.

BISMUTH.

2212. Metallic bismuth, crystallised.

Prepared in a crucible by allowing a large quantity to cool slowly, till a crust is formed on the surface, then breaking the crust and pouring the still liquid portion out. It has crystallised in hopper-shaped crystals belonging to the hexagonal system, but whose angles are so nearly right angles (87° 40′) that they look cubical.

2213. Crystallised bismuth showing iridescence.

This consists of the ordinary hopper-shaped crystals which have slightly oxidised in the air and have become covered with varying thicknesses of oxide. Exposure to iodine vapour is said to facilitate the formation of the film.

2214. Metallic bismuth cast in an ingot.

Shows the distinctive reddish tinge of the metal.

2215. Bismuth crystallised in an unusual form.

Consists of a number of rhombohedral plates and prisms, covered with metal hardly crystallised.

2216. Bisulphide of bismuth.

Prepared by precipitating chloride of bismuth by sulphuretted hydrogen. It is a black-brown powder which, when heated, takes the form of bismuthite, one of the ores of the metal.

2217. Bisulphide of bismuth.

Produced by fusing one equivalent of bismuth with one of sulphur, and pouring the molten mass into a mould. It is a dark reddish-grey metallic mass of fine fibrous structure, radiating from the sides of the mould. Prepared by W. Baker.

2218. Crystals of bismuth amalgam.

Four parts, by weight, of mercury have been mixed with one part, by weight, of bismuth in powder, and the amalgam thus formed has been allowed to stand for a year or two, in which time these crystals formed on the surface of the liquid. They have been examined by Professor W. H. Miller. They are sectile and flexible, and probably therefore contain mercury in their composition, and may be analogous to the crystalline alloy of antimony and zinc. *See* No. **1308.** They are here in the form of oblique pyramids, with truncated angles.

2219. The amalgam of mercury and bismuth, in which the above crystals formed after standing a long time.

Experiment by R. Smith.

2220. Amalgam of equal parts of mercury and bismuth.

Powdered bismuth in large quantity has been mixed with mercury, and the mixture kept. A very brilliant white amalgam has formed, with irregular fracture, and some portions have taken a crystalline external form, viz., an oblique prism, apparently not rhombohedral.

2221. Alloy of four equivalents of bismuth with one of nickel.

416 grains of bismuth were fused with 30 grains of nickel. The result is an irregularly granular, semi-fibrous, dark grey alloy. Experiment by R. Smith.

2222. Stereotype metal plate, made of fusible metal.

Accompanying this is the negative in prepared pasteboard, of which a stereotype is to be taken. Upon such a negative the metal is poured in a molten state. Its composition has to be such that it will not destroy the negative at the temperature of fusion. The essential ingredient of such a composition is bismuth. If half the alloy is bismuth, one quarter lead, and the rest tin and cadmium, the melting point is only 60·5° C.; moreover, the bismuth expands in solidifying and takes a sharp impression.

MERCURY.

2223. Cinnabar ore. From Almaden, Spain.

The original locality whence mercury was earliest obtained, and from whence the name of the ore is derived. It is a sulphide containing, when pure, 86 per cent. of mercury. Communicated by C. de Andrade.

2224. The exhausted residue from cinnabar ore. Almaden.

The massive nature of these residues shows that the mercury is a sublimation filling up the interstices in an ordinary rock bed. The ore is simply heated and the mercury sublimes.

2225. Massive cinnabar, very rich in the ore.

Mostly in the crimson crystalline form and partly in the earthy scarlet form.

2226. Cinnabar from Cyprus.

Partly massive and partly powder. Communicated by E. T. Wakefield.

2227. Vermilion ore from Algeria.

From the Province of Constantine, twelve hours south of Batna. Discovered in 1875. The amorphous red powder is the sulphide of mercury. The ore yields 5 per cent. of mercury. Communicated by J. C. Deane.

2228. Vermilion ore from Algeria.

The pure powder extracted from the rock.

2229. Crystallised cinnabar ore.

Yields 63 per cent. of mercury.

2230. Onofrite from Mexico.

Another ore of mercury containing selenium. The published analyses give selenium 6·42, sulphur 10·30, mercury 81·63 per cent. It is dark steel-grey in colour and is found impregnating the material of a vein.

2231. Sulphide of mercury, sublimed.

Crystalline form of the sublimate corresponding to cinnabar.

2232. Sulphide of mercury in a black powder.

Produced by triturating metallic mercury with warm powdered sulphur.

2233. Sulphide of mercury, sublimed and pulverised.

Corresponding to the red amorphous vermilion powder of the ore.

2234. Iron sulphide, produced by decomposing vermilion with iron filings with the aid of heat.

2235. Chloride of mercury or calomel.

In crystals composed of tetragonal prisms and pyramids, yellowish grey and transparent. Found at Altwasser in Upper Hungary, where the mercurial fallow ores are worked for their copper, mercury being obtained as a bye-product. The ores are roasted in mounds, and this incrustation was obtained at eight fathoms distant from the place where the roasting occurred, and two fathoms deep in the earth.

ARSENIC.

2236. Metallic arsenic.

From the Harz. It has been deposited in crystals lying parallel to the axis of the cylinder or tube in which it has been formed. It is dark grey by tarnish, and shows the hexagonal prisms and pyramids of the rhombohedral system.

2237. Crystallised arsenious acid.

Three specimens. From Muldener Hütte, Freiberg. These transparent octahedral crystals are formed on the surface of the roasting heaps, when the ores of copper, &c. contain a considerable quantity of arsenides. These are oxidised to form the arsenious acid, which is accompanied by red masses of realgar, formed by the combination of other portions of the arsenic with the associated sulphur.

2238. Realgar from the roast heaps. Muldener Hütte, Freiberg.

Communicated by H. Bauerman, 1854. A red transparent glass of sulphide of arsenic.

2239. Crystals of arsenious acid.

Deposited on the upper layer of some pyritic ore during roasting in a heap. From Eldridge Mine, Buckingham County, U.S.A. Communicated by J. W. Baker. They are in well-formed semi-transparent octahedra, tinged with yellow.

2240. Realgar from China.

A native ore consisting of arsenic sulphide, containing 70 per cent. of arsenic. Some portions are darker coloured.

2241. Arsenious acid as a sublimate from copper works.

Obtained in the process of roasting arsenical ores in furnaces provided with chambers. It contains also some traces of realgar from the sulphur associated. From the Mines Royal Copper Works, Swansea.

2242. Orpiment from France.

A sesquisulphide of arsenic containing 61 per cent. of arsenic, together with arsenious acid. It is in the form of a yellow opaque glass. The depth of the colour depends on the proportion of the sulphur added to the arsenious acid for the fusion mixture.

2243. Orpiment from China.

This is the natural sesquisulphide of arsenic, of a more or less crystalline and fibrous form.

2244. Native orpiment.

In a dark tinted fibrous form. Communicated by R. Pearce. Locality not given. It is very tough, and the cleavage parallel to the macro-diagonal is highly perfect. The crystals resemble yellow talc.

2245. Arsenical ore ready for roasting.

From the Arsenic Works, Hayle, Cornwall, 1858. The ore is powdered mispickel, or arsenical iron pyrites.

2246. Residue thrown away at the Arsenic Works, Hayle, Cornwall, 1858.

This consists of the ground gangue of the ore after the sublimation of all the arsenious acid in the furnace.

2247. Arsenious acid from the condensing flue.

From the Arsenic Works, Hayle, Cornwall, 1858. This is the unrefined product, which still contains mechanically mixed particles of the gangue and fuel. It is known as "Giftmehl," or poison-flour, in Germany.

2248. Arsenical glass.

From the Arsenic Works, Hayle, Cornwall, 1858. This is the commercial form in which arsenic is used. It is a consolidated and purified arsenious acid. The powder first produced is submitted to a second sublimation with carefully regulated temperature, so that only the pure acid passes into the condensing cylinder, this is then heated to a higher temperature, under which the deposit consolidates into a glass. In this form it is nearly pure. When first made it is translucent.

2249. Illustration of the effect of light on arsenic glass, showing the cause of its opacity.

Two tubes contain sealed up within them pieces of arsenic glass, which when placed there were both translucent. The one has been exposed for many years to the light, and this has become opaque and white; the other has been covered during the same period with tin foil, this has retained almost entirely its translucency.

CHROMIUM.

2250. Metallic chromium.

Produced by strongly heating in an air furnace a mixture of chromic oxide with carbon. Experiment by R. Smith, 1888. A porous mass is produced, in which there is abundance of a metallic substance of a tin-white colour, mixed with darker material derived from the fuel. Chromium is used in the manufacture of particular kinds of steel.

2251. Mixture of chromic oxide and lime strongly heated.

Experiment by R. Smith, 1888. It has become a purplish-black powder.

2252. Chromic oxide obtained by heating mercurous chromate.

Prepared by C. Tookey, 1857. Forms a fine green pigment.

2253. Chromic oxide obtained from chromate of potash with a little carbonate of soda.

2254. Crystallised chromic oxide.

Obtained as a furnace product in the Baltimore Chrome Works. The amorphous green substance has entered into the crevices and pores of the brick. Some of this is also transparent and crystalline. On part of the surface are numerous black semi-metallic hexagonal scales of chromium? *See* American Journal of Science, vol. X., p. 352.

2255. Hydrate of chromic oxide.

Prepared by treating lead chromate with hydrochloric acid and alcohol, precipitating the solution with hydrosulphuric acid, evaporating to dryness, digesting with water, precipitating with sal-ammoniac and washing.

2256. Chromic sulphate.

The pale green form.

2257. Chrome alum, or potassium chromic sulphate.

In dark purple, almost black octahedra.

2258. Oxalate of chromium and potash.

This has the formula, $Cr_2O_3, 3\ C^2O^3 + 3\ (KO,C^2O^3) + 6\ H_2O$. Pale transparent purple crystals, in thin plates of the rhombic system.

2259. Molybdate of chromium.

Prepared by Dr. Percy in 1851. A light green powder.

2260. Chloride of chromium.

Obtained by heating chromic oxide and carbon in a stream of dry chlorine. It consists of peach-blossom coloured transparent scales.

2261. Chromate of copper.

Produced by precipitating sulphate of copper with chromate of potash.

2262. Sand composed of chromite.

In brilliant black octahedra. Analysed by Ch. Tookey, contains 30·30 per cent. of chromic oxide, the remainder being ferrous oxide and alumina. Locality not stated.

2263. Alloy of chromium and manganese, containing 40 per cent. of chromium, with the green glassy slag formed during the process.

200 grains of manganese dioxide were heated for two hours with 123 grains of chromium oxide and 85 grains of charcoal. The button weighs 197 grains, is not very brittle, and scratches glass.

2264. Green aventurine glass.

Discovered by Pelouze. The colour is due to spangles of oxide of chromium in a crystalline form. Communicated by Sir C. Wheatstone.

MOLYBDENUM.

2265. Metallic molybdenum.

In the form of a dark powder. Prepared by Dr. Percy in 1850.

2266. Molybdenum ore.

Consisting of the sulphide mixed with gangue, and the whole powdered.

2267. Sulphide of molybdenum, or molybdenite.

This is the native ore from which most molybdenum is obtained; it occurs massive.

2268. Molybdic acid (*a*).

Impure form. Prepared by Dr. Percy in 1850.

2269. Molybdic acid (*b*).

Partially purified. Prepared by Dr. Percy in 1850.

2270. Pure molybdic acid.

Prepared by Dr. Percy according to the method of Berzelius in 1850.

2271. Molybdic acid.

Prepared by Emile Rousseau of Paris. In all these cases it is a greenish-yellow powder.

2272. Anhydrous molybdic acid.

Prepared by dissolving the trioxide obtained by decomposing the ammonium molybdate by nitric acid, in a fresh portion of nitric acid and allowing the solution to evaporate in vacuo over sulphuric acid. It consists of small, transparent, colourless, prismatic crystals.

2273. Molybdate of ammonia.

Ordinary impure form prepared in 1847. Coloured green by the presence of copper.

2274. Molybdate of ammonia?

Prepared by Dr. Percy in 1850. Blue and green prismatic narrow crystals.

2275. Bimolybdate of ammonia.

Prepared according to Berzelius by Dr. Percy in 1851. Brilliant sea-green crystals of short prismatic habit.

2276. Molybdate of stannous oxide.

Prepared by Dr. Percy in 1851. A dark, nearly black amorphous substance in small fragments.

TUNGSTEN.

2277. Wolfram.

The ordinary ore of tungsten, composed of tungstate of iron and manganese. Associated with tin ore in Cornwall.

2278. Wolfram, carefully picked out and very finely powdered in an agate mortar for experimental purposes.

2279. Wolfram supposed to resemble zinc blende.

It was sold as zinc blende and assayed for zinc.

2280. Metallic tungsten.

Obtained by R. Oxland's process, at the Drakewalls Tin Mine, Cornwall. The wolfram picked out from the tin ore, as well as the tin ore contaminated by wolfram, is fused with soda ash and sodium nitrate in a reverberatory furnace, and the soluble sodium tungstate dissolved out and obtained by crystallisation. From this the tungsten trioxide can be precipitated by nitric acid, and the metallic tungsten obtained by reduction by carbon in a covered crucible.

2281. Metallic tungsten in powder.

Produced by Th. Kniesche, Rosswein, Saxony. Analysed at the Royal Forge Laboratory, Freiberg. Gives 97·4 per cent. of metallic tungsten, 1 per cent. of tin, and 1·16 per cent. of carbon, without any trace of copper, arsenic, or sulphur. It is produced for melting with steel to improve its hardness and tenacity for tools.

2282. Blue oxide of tungsten crystallised.

This is a mixture of two equivalents of the trioxide with one of the dioxide, obtained by partially reducing the trioxide in a current of hydrogen. It is nearly black, and is not crystalline in form, but only in lustre.

2283. Tungsten prepared by reduction.

2284. Tungsten grains left after dissolving an alloy of tungsten and silver in nitric acid.

2285. Compound obtained by boiling the white precipitate of tungsten trioxide by nitric acid in aqua regia.

A bright yellow powder, consisting of purified tungsten trioxide.

2286. Impure tungstic acid.

Precipitated by acid from a tungstate ; a brown powder.

2287. Pure tungstic acid.

Prepared by Dr. Percy, after the method of Berzelius, by dissolving tungstic oxide in sulphide of ammonium and treating with hydrosulphuric acid. It forms a light green powder.

2288. Sulphide of tungsten.

Prepared by Dr. Percy in 1845, and treated with dilute hydrochloric acid. It is a very brilliant black crystalline powder. Probably produced by heating tungsten trioxide with cinnabar.

2289. Tungstate of soda.

The ordinary product of tungsten ores, obtained by fusing them with soda ash and lixiviating. In white crystals.

2290. Tungstate of soda.

An impure form of brownish tint, but in larger crystals.

2291. Tungstate of ammonia.

Prepared by Dr. Percy. Yellowish-white, needle-shaped, and platy crystals.

2292. Tungstate of ammonia.

In minute white needle-shaped crystals.

2293. Tungstate of ammonia.

In small needles with short crystalline particles.

2294. Tungstate of baryta.

In the form of a white amorphous powder. Prepared by Messrs. Lister and Biggs.

URANIUM.

2295. Powdered pitchblende.

Various samples of the ore from Cornwall. Communicated by A. W. Bell. The uranium is contained in these ores in the form of uranoso-uranic oxide. No. 1 contains 49·1 per cent. of this oxide. No. 2 contains 56·5 per cent. No. 3 contains 57·35 per cent. No. 4 contains 50·01 per cent. A fifth sample, "ex Nevada," contains 55·47 per cent. of the same oxide.

2296. Hydrated oxide of uranium.

Obtained by evaporating a solution of uranic nitrate ; a bright yellow powder.

2297. Nitrate of uranium.

In lemon-yellow fluorescent rhombic prisms, partially deliquesced, obtained by dissolving uranium oxide in nitric acid.

2298. Phosphate of uranium.

A light green powder, obtained by heated uranium oxide with phosphoric acid.

2299. Uranate of barium, precipitated hot.

Prepared by C. Tookey in 1874, by precipitating a mixture of nitrate of uranium and nitrate of baryta with ammonia. This has a light yellow tint.

2300. Uranate of barium, precipitated cold.

Prepared by C. Tookey in 1874. Precipitated from the same solution as No. **2299** after it had become cold. This has a deeper tint. With it is the same, as it appeared when dry.

TANTALUM, COLUMBIUM, AND YTTRIUM.

2301. Columbite from Middletown, Massachussets.

Communicated by Mr. Brooke. This dark-coloured mineral is said to contain 28·5 per cent. of tantalum oxide and 51·5 per cent. columbium oxide in combination with 13·5 per cent. of ferrous oxide.

2302. Tantalite from Sweden.

This contains 49·6 per cent. of tantalum oxide and 29·2 per cent. columbium oxide in combination with 13·7 per cent. of ferrous oxide.

2303. The mineral called Torreylite, from the Andover Iron Mines, New Jersey, O.S.

The name is now changed to Columbite. It is a columbate of iron; massive and red.

2304. Yttrotantalite from Ytterby, in Sweden.

This mineral contains 10 per cent. of tantalum oxide, 42 per cent. of columbium oxide in combination with 27·7 per cent. of yttrium oxide, and 12·4 per cent. of erbium oxide.

2305. Tantalite from Frinnitto, Finland.

This ore contains 76·3 of tantalum oxide and 7·5 per cent. of columbium oxide with 13·9 per cent. of ferrous oxide.

METALS OF THE CERIUM GROUP.

Cerium.

2306. Gadolinite from Finland.

This is the original ore in which the metals of this group were discovered by Gadolin in 1794. It is a silicate of these and other metals, and contains 34·64 per cent. of yttrium, 2·86 of cerium, 2·93 of erbium, 8·38 of didymium, and 3·21 per cent. of lanthanum. It is black and semi-vitreous.

2307. Cerite, powdered.

Another ore of cerium, occurring as a band in gneiss at Barnas, in Sweden. It contains 61 per cent. of cerium with 3·5 per cent. of lanthanum and 3·90 per cent. of didymium.

2308. Cerium metal in the form of a greenish-grey powder.

Obtained by heating the chloride with sodium.

2309. Cerium dioxide.

A pale straw-yellow powder, prepared by Bunsen's method from cerite by first precipitating the oxalate from a highly acid solution of the ore, heating this oxalate, dissolving in nitric acid, evaporating, precipitating the cold water solution by strong sulphuric acid, and dissolving in dilute, and precipitating by caustic potash. *See* Bunsen, Phil. Mag., vol. 4, p. 533.

2310. Ceric oxide.

A fine white powder, probably identical with the last, prepared by a different process.

2311. Cerium fluoride, mixed with fluoride of silicon and strongly heated.

Is of a pale straw-yellow powder.

2312. Sesquifluoride of cerium.

A pinkish-white powder. Usually obtained by acting on ceric oxide with hydrofluoric acid.

2313. Hydrated cerium chloride.

Obtained by dissolving sesquioxide of cerium in hydrochloric acid and precipitating with sal-ammoniac. Of a bright yellow tint.

2314. Cerium phosphide.

A dark grey mass, broken into small fragments. Produced by heating cerium dioxide to whiteness in a current of phosphuretted hydrogen gas. It usually contains some phosphate of cerium.

2315. Cerium sulphide.

Obtained by heating cerium dioxide with sulphur. If heated in the air alone it takes fire, or is pyrophoric.

2316. Nitrate of cerium.

Produced by acting on sulphate of cerium with nitrate of barium, when a double decomposition takes place. It is a desiccated crystalline powder.

2317. Carbonate of cerium.

Produced by adding carbonate of ammonia to a solution of the sulphate; a crystalline powder.

2318. Oxalate of cerium.

This is the crude product containing oxalates of cerium and its allied metals, from which all the other salts are derived. It is obtained from cerite by treating the powdered ore with sulphuric acid, and precipitating the solution saturated with hydrochloric acid, and oxidised by chlorine, by means of oxalic acid. A white powder.

2319. Oxalate of cerium, still containing lanthanum and didymium.

A pinkish powder.

2320. Purified oxalate of cerium.

Obtained by repeating the above process with suitable modifications. The cerium sulphate being insoluble, while those of the associated metals are soluble.

2321. Cerium residues, consisting of brick-red powder.

LANTHANUM.

2322. Lanthanum mixed with oxychloride of lanthanum.

A greyish powder. The metallic lanthanum produces a grey colour, the oxychloride being obtained by passing chloride over the heated oxide at 200°. It is a white powder; by heating the chloride with potassium the metal is obtained.

2323. Lanthanum sulphide.

Obtained by calcining the oxide of lanthanum in the vapour of carbon disulphide. It is a yellow mass which decomposes when brought in contact with water.

2324. Anhydrous sulphate of lanthanum.

Obtained by calcining the hydrated sulphate at a heat below red heat. It is a pinkish-white powder. It dissolves more readily in cold water than in hot. The hydrated sulphate is thus obtained from the mixed ore of cerium, lanthanum, and didymium, by warming the mixed sulphates till that of lanthanum precipitates.

2325. Carbonate of lanthanum.

A brownish-yellow powder, obtained as a precipitate on adding an alkaline carbonate to any of the soluble salts.

2326. Mixed anhydrous sulphates of lanthanum and didymium.

This is the product of calcining the original sulphates below a red heat. These are obtained by treating the native mineral with sulphuric acid. It is the starting-point of all the salts of these two metals, and hence of their own separation.

DIDYMIUM.

2327. Didymium with oxychloride of didymium.

This is produced by heating the oxide in a current of chlorine. It is a grey powder, which when heated with potassium is partly converted into the metal. The oxide may be obtained by igniting the sulphate.

2328. Didymium sulphide.

A greenish-brown powder. Obtained by calcining the oxide in the vapour of bisulphide of carbon.

2329. Crystallised sulphate of didymium.

This is the primary source of all the didymium compounds, and thence of the metal itself. It is the last to be extracted from the product of treating the ore with sulphuric acid. After the mixed lanthanum and didymium sulphate has been obtained, and the salt of lanthanum has been precipitated by heating the solution, the remainder is precipitated by oxalic acid, the first permanent precipitate being richest in didymium; this is again converted into sulphate, and the process repeated till purity is attained. It consists of rose-red tabular crystals.

2330. Anhydrous sulphate of didymium.

Prepared by heating the crystallised salt to 200° F. It forms a pink powder.

MAGNESIUM.

GENERAL EXPERIMENTS.

2331. Metallic magnesium cast into the form of a medal.

This was cast in 1851, and has on the obverse the head of Prince Albert and the inscription "H.R.H. Prince Albert, President of the Royal Commission," and on the reverse a globe and the word "Exhibition" across it and the inscription "Exhibition of the works of industry of all nations, MDCCCLI." At this date metallic magnesium was a metallurgical curiosity. It has now entirely oxidised on the surface.

2332. Oxide of magnesium.

Prepared from oxidised amalgam of mercury and magnesium, by igniting it in a closed tube.

2333. Magnesium heated in benzole.

Apparently a mixture of white oxide of magnesium, with the reduced carbon from the benzole.

2334. Carbonic dioxide decomposed by magnesium (two examples).

Magnesium has been burned in carbonic dioxide, and the result is a quantity of magnesia in blebs on the surface of carbon reduced from the gas.

2335. Result of heating together equal parts of alumina and magnesium.

The alumina was freshly prepared and pure. The product is a dark pulverulent mass, apparently produced by the volatilisation of the magnesium, and the concomitant reduction of the alumina. *See* No. **2365.**

2336. Result of strongly heating together magnesia and alumina.

This is a white, and apparently unaltered powder, for comparison with the product of the last experiment, showing the action of the metallic magnesium.

2337. Result of heating silica with magnesium.

A sub-metallic scoriaceous mass is produced, apparently a compound of the two elements, *i.e.* a silicide of magnesium.

2338. Result of heating silica and magnesium in an atmosphere of hydrogen.

The product is a dark grey pulverulent mass, formed by the reduction of the silica.

2339. Result of heating together 2·4 grains of magnesium with 1·5 grain of silica.

The result is a scoriaceous mass like No. **2337.**

2340. Result of heating together 2 grains of magnesium with 1½ grain of silica.

The result cannot be distinguished from that of the last; the magnesium not required for combination probably volatilising.

EXPERIMENTS ON THE PRODUCTION OF PHOSPHIDE OF MAGNESIUM.

2341. Phosphorus and magnesium heated in pure hydrogen, in an ignition tube, and sealed up in hydrogen.

The contents of this tube since the heating have never been in contact with the air. The tube has a mass of dark sub-metallic appearance which is the true phosphide of magnesium.

2342. Phosphorus and magnesium heated in a bulb tube and sealed up as quickly as possible.

This shows the effect of the air in the result of the union of these two elements. The bottle contains a quantity of a dull grey powder into which the phosphide of magnesium ordinarily decomposes.

2343. Phosphide of magnesium, prepared in hydrogen, but allowed to come in contact with the air.

It has immediately oxidised and become a dull grey powder.

2344. Phosphide of magnesium.

Prepared by heating amorphous phosphorus with magnesium to redness in a bulb tube. The greater part of this has decomposed, but some is dark and massive.

2345. Phosphide of magnesium.

Prepared by igniting magnesium filings in melted phosphorus in a current of hydrogen. It is the same dull grey powder.

2346. Phosphide of magnesium.

Prepared by igniting magnesium wire and ribbon in hydrogen with melted phosphorus in the same way as the filings in No. **2345.** The metal has not been entirely acted on by the phosphorus.

2347. Magnesium wire and ribbon heated in melted phosphorus and in hydrogen.

This is not entirely combined, but consists in part of magnesium merely coated with the phosphide, and a dark sub-metallic mass which has undergone fusion, and is the true phosphide.

2348. Magnesium wire and ribbon heated to redness in a bulb tube with phosphorus.

This has not been fused, and retains the shape of the original ribbon. It is probably only coated with the phosphide.

2349. Magnesium wire and ribbon heated in a current of hydrogen and phosphorus vapour.

This has been partially oxidised by exposure to the air, by which the usual grey powder has been formed, but the wire and ribbon have only been partially acted on by the vapour of phosphorus.

2350. Phosphide of magnesium added to dilute sulphuric acid.

At the time of adding it, all the phosphorus in the compound immediately escaped in the form of phosphuretted hydrogen, and what is left in the acid consists of magnesia with a trace of phosphorous acid and a brown residue derived from the corrosion of the glass by the magnesium in the combustion.

2351. Falsely called black phosphide of magnesium.

This is really produced by the combustion of magnesium in carbon dioxide, and contains no phosphorus at all, though the combustion may have taken place in the presence of phosphorus. *See* No. **2334.**

2352. Reproduction of the falsely called "stable phosphide of magnesium."

Magnesium filings have been ignited in a current of carbon dioxide and phosphorus vapour at a red heat. The product has been added to this bottle of dilute sulphuric acid. The result is the precipitation of insoluble carbon. This is the so-called "stable" phosphide of magnesium which is seen by the above products to be non-existent.

ALLOYS OF MAGNESIUM.

2353. Alloy of magnesium and arsenic.

15 grains of arsenic have been heated in hydrogen with 13 grains of magnesium. A slight explosion occurred, and the metals united, but immediately on exposure to the air the product exploded, and became a fine brown powder.

2354. Alloy of magnesium and antimony.

Prepared in a mixture of salt and fluor-spar. It is metallic within, but the entire surface has deeply oxidised into magnesia, &c.

2355. Alloy of magnesium and antimony fused in hydrogen.

This is a dark porous and only slighty metallic mass.

2356. Alloy of magnesium and tin.

Prepared in fluor-spar and salt. A clean surface has been produced by filing, and the alloy sealed up immediately. The surface is speckled by black dots on a white metal ground.

2357. Alloy of magnesium and tin.

Prepared in fluor-spar and salt, but not sealed up. This is entirely tarnished, and coated with a considerable thickness of oxidised material.

2358. Alloy of magnesium and tin.

Prepared in a brasqued crucible and sealed up at once. This is not at all tarnished on the broken surfaces. It is a bluish-white irregularly cleaving metallic substance.

2359. Tin alloyed with 10 per cent. of magnesium.

Prepared by melting the two metals together in a current of hydrogen; a bluish-grey granular metallic mass adhering to the glass.

2360. Tin alloyed with 5 per cent. of magnesium.

This has a very similar appearance to the last. It is partly cohesive when cut. It has been prepared in the same manner as the last.

2361. Tin alloyed with 2 per cent. of magnesium.

This shows much less difference from tin. It is duller and somewhat tarnished. It has been prepared in the same manner in hydrogen.

2362. Alloy of aluminium and magnesium.

Produced by fusing aluminium and magnesium together in cryolite and fluor-spar. It is a white sub-crystalline metallic substance, not at all tarnished on the fractured surface.

2363. Alloy of aluminium and magnesium.

Prepared by fusing the metals together beneath salt, and sealing up the product. It is a brilliant white metallic substance, without tarnish, with an irregular fracture.

2364. Alloy of aluminium and magnesium.

Prepared in a crucible of magnesia. At the heat of union a large proportion of the magnesium escapes, so that the resulting alloy, which is highly porous from the escape of the vapour, retains on analysis only 0·86 per cent. of magnesium.

2365. Alloy of aluminium and magnesium.

49·5 grains of aluminium and 20 grains of magnesium were taken and fused together in a crucible of freshly calcined magnesia (*see* No. **2366**). Most of the magnesium volatilised, and an irregular, porous, grey metallic mass is left.

2366. Brasque of freshly calcined magnesia blackened by carbon.

The carbon is derived from the action of the magnesium vapour in the substance experimented upon, on the trace of carbon dioxide which the magnesia contained, and which the metal has decomposed.

2367. Alloy of cadmium with 10 per cent. of magnesium.

Prepared by fusing the metals together in a current of hydrogen. This specimen has been sealed up at once; it is untarnished, and shows a brilliant white, platy, and crystalline metallic fracture.

2368. Alloy of cadmium with 10 per cent. of magnesium.

This was prepared in the same manner as the last, but it was not immediately sealed up. It has in consequence crumbled and oxidised, and consists of dark-coloured small metallic fragments with flat surfaces.

2369. Alloy of lead with 7 per cent. of magnesium.

Prepared by fusing the two metals in a current of hydrogen. The fracture is dark bluish-grey, with a fibro-crystalline structure; the sectility of the lead is unaltered.

2370. Alloy of lead and magnesium.

Prepared in fluor-spar and salt. This has entirely disintegrated on the surface, not having been sealed up. It is a mass of red oxide mixed with yellow and grey. The surrounding glass appears also to have been attacked where the metal has been in contact with it.

2371. Alloy of zinc and magnesium.

Prepared by melting the two metals together in a current of hydrogen. The product is tarnished and porous, but does not appear to be greatly altered by exposure to the atmosphere.

2372. Alloy silver with 10 per cent. of magnesium.

Prepared by melting the two metals together in a current of hydrogen. It has a somewhat yellow tarnish.

2373. Amalgam containing 4 per cent. of magnesium.

The mercury is for the most part unaltered, but the magnesium has formed with part of it a loose light yellowish-brown powder.

2374. Amalgam containing 7 per cent. of magnesium.

Appears to have been prepared in a different manner from the last. It consists of an immovable mass with a black powder.

2375. Alloy of copper and magnesium.

The two metals have been fused together, surrounded by salt and fluor-spar. The product is not homogeneous, but shows on the fractured surface an intermingling of copper-coloured spots with irregular fibres, and darker tinted areas of a fibro-crystalline structure.

2376. Alloy of bismuth and magnesium.

Prepared by fusing the two metals together in fluor-spar and salt. It is a dark compact mass, which has for the most part oxidized into a white powder.

2377. Alloy of bismuth with 10 per cent. of magnesium.

Prepared by fusing the two metals together in a current of hydrogen. It consists of a brittle, fractured, black charcoal-like mass.

2378. Alloy of bismuth, magnesium, and copper.

Prepared by fusing certain proportions not stated, of the three metals in fluor-spar and salt. The union of the metals is not complete, the filed surface having a blotched aspect, and the fracture is fibro-crystalline. It has a coppery appearance.

2379. Attempt at an alloy of iron and magnesium.

Iron and 15½ per cent. of magnesium were fused in graphite, but no magnesium is found in the product, it having volatilised before entering into combination.

2380. Attempt at an alloy of cobalt and magnesium.

The two metals have been fused together in a brasqued crucible. The magnesium has all volatilised, and none is left in the product, which is a highly porous mass.

2381. Attempt at an alloy of nickel and magnesium.

The two metals were fused together in a brasqued crucible, but very little magnesium has been taken up by the nickel, the analysis being nickel 95·340, magnesium 0·055, graphite 4·600.

2382. Alloy of nickel and copper with magnesium.

100 parts of nickel and 270 parts of copper were taken so as to form the best German silver, without the usual zinc, for which magnesium has been substituted. It has a fibro-crystalline structure, and a yellow tarnish.

2383. Another product of the substitution of magnesium for zinc is German silver.

The same proportions as in No. **2382** have been taken. The result is a grey mass with a granular fracture, and iris tarnish. On analysis it yields copper 65·63 per cent., nickel 28·24 per cent., and magnesium 6·34 per cent.

GLUCINUM.

2384. Glucina.

A light brown soft powder. Impure oxide of glucinum or beryllium.

2385. Purified glucina.

A white powder.

2386. Phosphate of glucina.

A white powder.

2387. Carbonate of glucina.

A white powder.

ALUMINIUM.

EXPERIMENTS.

2388. Lime and alumina heated together in platinum in the proportion of their equivalent numbers.

It still remains a white powder without visible reaction.

2389. Ferric oxide and alumina heated together in platinum in the proportion of their equivalent numbers.

It still remains a red powder, slightly aggregated together, but with no further visible reaction. A portion has been re-heated to the temperature at which, in another experiment, lime and ferric oxide fused, but without any change taking place.

2390. Magnesia and alumina heated together in platinum in the proportion of their equivalent numbers.

It still remains a white powder without visible reaction.

2391. Pellets produced by mixing alumina with one-third of its weight of charcoal powder into a stiff paste with oil, and calcining in a covered crucible.

Experiment by R. Smith. The hardest part of the pellet is the coat, which shows a graphite looking network.

2392. Cryolite from Greenland.

A fluoride of aluminium and sodium, which is used as an ore of aluminium. Communicated by T. Reeks.

VARIOUS FORMS OF THE METAL.

2393. Piece of aluminium wire.

2394. Pieces of sheet aluminium.

2395. Piece of seamless aluminium tube.

Prepared by A. Parkes, Birmingham, according to his patent.

2396. Ingot of aluminium.

Made in France, where the process of H. St. Clair Deville was first introduced. 400 parts of the double chloride of aluminium and sodium with 200 parts of fluor-spar or cryolite, and 200 parts of common salt are dried and mixed together. The mixture is then laid in alternate layers with 80 parts of metallic sodium in small pieces. This on a large scale is strongly heated in a furnace. At the end of the process the slag is tapped first and the aluminium is extracted later.

2397. Aluminium made from cryolite.

Cryolite was powdered with half its weight of salt and placed in alternate layers with two parts of sodium. The resulting metal has been rolled out into thin plates. The operation was performed by A. Dick for Dr. Percy in 1855, and these specimens (the first to be made from cryolite alone), were exhibited by Professor Faraday at the Royal Institution the same evening.

2398. Aluminium made by the Deville process.

By A. Dick in the laboratory of the Royal School of Mines. Part has been beaten out to show the malleability of the metal.

2399. Aluminium prepared from cryolite by means of sodium.

Made by F. W. Gerhardt in 1858 by Dr. Percy's process, as in No. **2397.**

ALLOYS OF ALUMINIUM.

2400. Sheet of aluminium said to contain platinum and iridium.

Communicated by W. Meredith. It is of a brilliant white colour and completely untarnished.

2401. Alloy of aluminium and zinc.

A dark grey fractured lump. Made in Dr. Percy's laboratory in 1856.

2402. Alloy of aluminium and iron.

100 grains of each of the metals have been fused together by R. Smith. The result is a broken grey mass disintegrating to powder, or divided by many fissures.

2403. Alloy of aluminium and copper.

90 per cent. of copper and 10 per cent. of aluminium. It has a brassy aspect and is much tarnished. Part of the ingot has been rolled out into a sheet, and part has been drawn out into a wire. Communicated by D. Forbes, 1857.

2404. Alloy of aluminium and copper tested for electric conductivity.

The electric conductivity of copper being taken as 100, and that of pure aluminium at 33, the electric conductivity of this wire is only 12·7. Tested by Dr. Matthiessen in 1872.

ILLUSTRATIONS OF THE PROCESS OF MAKING ALUMINIUM ALLOYS BY MEANS OF COWLE'S ELECTRIC FURNACE.

This process consists essentially of producing an intense heat, not otherwise obtainable, by passing a strong electric current through a very resisting medium. A column of fragments of well calcined charcoal, so prepared and arranged as to present the requisite electrical resistance, is imbedded in pulverized charcoal, and covered by a layer of the same coarsely broken; the whole being arranged in a box of fire-brick covered with a perforated tile. Through these the current from a dynamo-electric engine of 30-horse power is made to traverse the central core of carbon, and thus produce an enormously high temperature.

2405. Corundum used for the extraction of aluminium in the electric furnace.

This is reduced to small fragments and mingled with the carbon in the path of the current, when aluminium is rapidly liberated, and is in part carried off with the escaping gas and in part condensed in the upper layer of charcoal.

2406. Granulated copper as it is charged into the electric furnace.

When this is mixed with the corundum in the path of the current an alloy of the two metals is obtained.

2407. End of a carbon which has been used in combination with several others to form the electrode in the electric furnace.

It is changed in several parts of the surface into graphite, a change which takes place readily at a high temperature in the presence of aluminium or of iron. In the absence of either of these metals, the change into graphite is much less readily effected, and in smaller amount. It very commonly happens that the woody structure of the charcoal is retained in the graphite, which shows that the change has taken place without fusion or solution in the metal.

2408. Bye product from the incomplete reduction of alumina in the electric furnace.

These are fragments of a glittering black, metallic-looking substance, adhering to pieces of the carbon, and resembling graphite in appearance. It comes from the runs where the copper is highly charged with aluminium, in the process of making aluminium bronze, and a large amount of the aluminium has been extracted from the ore charge. It contains rich globules of the copper aluminium alloy, and is very common in the furnace, but has not been analysed.

2409. Crystalline bye product in the electric furnace.

It is a green slag with a surface of interosculating crystalline plates. It has a very perfect cleavage in one direction and two imperfect ones in two others, oblique to the first. It is glassy in lustre and semitranslucent. According to a rough analysis it is an aluminate of lime, or an artificial lime-spinel, a mineral not hitherto obtained. There is nothing in the furnace beyond the corundum with 5 to 8 per cent. of silica, copper, charcoal, some of which has been washed in strong milk of lime. This is one of the main bye products of the process.

2410. Sublimate which condenses in the upper part of the electric furnace where it is cooler.

Probably consists of amorphous powder of metallic aluminium, with some alumina which is oxidized by the air which obtains access to the furnace.

2411. Bye product in the process of reducing aluminium in the electric furnace.

This is a fused mass of the same kind of material as No. **2408.** It probably contains a certain amount of unreduced corundum.

2412. The alloy of aluminium and copper as it first comes from the electric furnace.

It is an irregular mass, mixed up with pieces of charcoal, and about ¾ in. in thickness. It has a whitish-yellow appearance, and yields on analysis 12 per cent. of aluminium, 2 per cent. of silicon, and 86 per cent. of copper.

2413. Ingot of high-grade aluminium bronze, made in the electric furnace.

This has been recast from the first product. It has a whitish-yellow colour and a crystalline fracture. This alloy is remarkable for its great tensile strength. It requires a breaking weight of 102,000 lbs. to the square inch, while rolled steel plates require only 81,000 lbs. It elongates to the extent of 4 per cent. before breaking. The alloy contains from 10 to 11 per cent. of aluminium, and is considered to be a true compound of one equivalent of aluminium with nine of copper.

2414. Alloy of aluminium and iron.

As produced in the electric furnace in the first stage. A rough mass about ¾ in. thick with a coarsely crystalline fracture and brilliant steel-grey metallic lustre. This is usually accompanied by a large quantity of flaky graphite, which has apparently been in solution in the iron and is given off during cooling.

2415. Alloy of aluminium and iron, as re-melted and cast into an ingot.

This contains on analysis 2·86 per cent. of silicon, and 8·38 per cent. of aluminium, the remainder being iron and carbon. It has a dull grey, finely granular fracture. The value of this alloy is not so much in itself as for mixing with iron and steel, so as to introduce a smaller percentage of aluminium. An addition, amounting to ·2 per cent., renders the melting point much lower, or increases the fluidity of already molten iron or steel, thereby rendering the castings free from blow-holes and sharp. This is particularly the case with wrought iron or Mitis castings. This ingot has not in any way oxidized, the aluminium acting as a preventive.

INDIUM.

2416. Metallic indium.

Prepared and communicated by M. Richter of Freiberg, who discovered it in 1863. It is obtained from the zinc which is smelted at Freiberg by treating it with insufficient hydrochloric acid to dissolve all the zinc, and leaving the solution to stand. The indium is thereby precipitated on the zinc and is afterwards purified. It is soft enough to be scratched by the nail. It has not at all tarnished since its preparation.

2417. Indium oxide.

Prepared and communicated by M. Richter. It is a pale yellow powder, prepared by strongly heating the sulphide.

2418. Indium sulphide.

Prepared and communicated by M. Richter. It is a dark brown glassy mass, prepared by heating together sulphur and indium at a heat below redness.

MISCELLANEOUS METALS.

2419. Sodium preserved in dry oxygen.

The metal has been melted in a glass tube, which has been broken up and enclosed in a larger tube. This has been filled with dry oxygen and sealed up. The contents have been enclosed for 30 years, but the sodium, though tarnished, is not otherwise changed.

2420. Impure titanium.

Mixed with titanium oxide and titanide of iron, &c. A black powder probably derived from menaccanite.

2421. Pure titanic acid, in the form of a greenish-grey powder.

VARIOUS NON-METALS OCCURRING IN METALLURGICAL OPERATIONS.

Selenium.

2422. Selenium.

From the Mansfeld Copper Works. Exhibited at the International Exhibition in 1862. It has been cast in long sticks. This was originally and is still obtained from a deposit formed in sulphuric acid chambers, where certain minerals are used. It is originally in red flakes, but is cast in sticks by melting and cooling to 210°. It thus obtains a metallic lustre.

2423. Solid selenium.

A mass with a metallic lustre prepared by Professor Mitscherlich of Berlin. Communicated by Professor W. H. Miller.

2424. Bust of Berzelius in selenium.

An oval medallion cast in selenium, with "Batka dedic." on the reverse side. Berzelius discovered selenium in Sweden in 1817. From the International Exhibition of 1862.

TELLURIUM.

2425. Tellurium.

Artificially prepared. Showing a very metallic lustre and a fibrous structure. It is bluish-white when fresh, but tarnishes yellow. In one specimen it has been cast into a stick form, in another it has been melted in a crucible and allowed to crystallise, showing rhombohedral forms.

2426. An ingot of tellurium.

Melted and cast in rectangular form. This operation has to be performed in an atmosphere of hydrogen.

BORON.

2427. Adamantine boron.

Four tubes of different forms of the element, prepared and communicated by H. St. Clair Deville. One of these is in very small crystals, another in larger, and a third is well formed crystals, consisting of monoclinic prisms with pyramidal ends. These are black. A fourth tube contains more transparent yellowish-brown crystals. This form of boron is invariably produced by the aid of aluminium, and retains some of this metal in its composition.

2428. Boride of aluminium.

This is the so-called graphitic boron. It consists of thin plates of a gold-tinted, metallic-looking, opaque substance, which has been shown to consist of one equivalent of aluminium to two of boron. Prepared and communicated by H. St. Clair Deville.

2429. Amorphous boron.

The ordinary form of a brown powder. Prepared in France.

SILICON.

2430. Various forms of silicon.

Three tubes containing the element, prepared and communicated by H. St. Clair Deville. One is the ordinary amorphous form (labelled A), another is the crystalline (labelled C), and the third is graphitoidal, *i.e.*, in thin plates (labelled G). Amongst the crystals (in C) octahedral forms can be easily seen, and they are often twinned. The graphitoidal forms have been examined by Professor Miller, who reports that they belong to the cubic system, and are octahedra, thin in one dimension, some being twins, like the twins of magnetite. It is to be noted that this form is also obtained by the aid of aluminium (*see* No. **2428**) in Deville's process. *See* Percy's Metallurgy, Iron and Steel, p. 83.

2431. Crystallised silicon, prepared by the zinc and sodium process.

Prepared by St. Clair Deville. Communicated by Johnson, Mathey, and Co. This process consists in throwing a mixture of 30 parts of potassium silico-fluoride, 40 parts of granulated zinc, and 8 parts of finely divided sodium, into a red-hot crucible, kept for some time just below the boiling point of zinc. The product consists of fine plates composed of an indefinite number of small octahedra placed side by side, many being thin in one dimension. *See* Percy's Metallurgy, Iron and Steel, p. 83.

2432. Silicon prepared by aluminium.

Said to be made with silicon fluoride and aluminium mixed with a fluoride of aluminium and silicon. Prepared by H. St. Clair Deville. Communicated by Sterry Hunt. It is imperfectly crystalline and impure.

2433. Fused silicon.

Prepared by St. Clair Deville, and communicated by Johnson, Mathey, and Co. A solid mass, obtained by raising the product of No. **2431** above the boiling point of zinc.

2434. Crystalline silicon.

2435. Amorphous silicon.

Prepared in France. In a solid form.

2436. Silicon prepared from silico-fluoride of potassium, sodium, and silver.

This is an analogous process to that by which No. **2431** was produced, merely substituting silver for zinc. It consists of a pure black crystalline powder.

2437. Crystalline silicon.

Prepared by Dr. Percy in 1858. It consists of octahedral crystals of great brilliancy.

2438. Silicon produced in an experiment with iron and magnesium.

Magnesium and iron were heated in a clay crucible with cryolite and fluor-spar. The iron did not fuse, but silicon was found at the bottom of the crucible.

MANGANESE.

THE METAL AND COMPOUNDS.

2439. Pyrolusite or black oxide of manganese.

From the Travina Mine, Butte, Montana. Communicated by W. A. Clark. This ore contains 135 ounces of silver and 3 ounces of gold to the ton of 2,000 lbs.

2440. Rhodonite, or silicate of manganese.

From the Moulton Mine, Butte, Montana. Communicated by W. A. Clark.

2441. Manganese ore from Portugal.

The larger mass contains 83·78 per cent. of manganese binoxide, and the smaller lump 65·15 per cent. of the same. Communicated by Mr. Pithoriet.

2442. Metallic manganese.

Reduced from the oxide by heating with charcoal to a white heat. A grey brittle crystalline mass.

2443. Metallic manganese.

Prepared by Dr. Percy from its oxide by heating with carbon in a carbon-lined crucible. It has to a great extent disintegrated to powder. It speedily tarnished and evolved the odour of fetid hydrogen when breathed upon.

2444. Pure mangano-manganic oxide.

A brown powder produced by precipitation from manganous sulphate by carbonate of soda.

2445. Aluminate of manganese.

A pinkish powder.

2446. Oxysulphide of manganese.

Prepared by heating mangano-manganic oxide with excess of sulphur. It is a very dark brown powder.

2447. Phosphide of manganese.

Prepared in 1865. Consists of a mass of interlocking prismatic crystals, of a yellowish-grey colour and metallic lustre.

2448. White enamel, containing 3 per cent. of arsenic.

[Misplaced by error.]

2449. Manganiferous furnace product.

Produced in the furnaces at Clausthal in the Harz, where mixed ores are used. This is produced when manganiferous ores have been employed. Communicated by Mr. Voelcker. It is a red transparent crystalline coating resembling a silicate.

ALLOYS.

2450. Alloy of manganese and copper.

Prepared and communicated by J. F. Allen in 1870. This alloy is produced directly from the oxides of the two metals, which are ground with wood charcoal, and intimately mixed, and placed in a plumbago crucible, which is then heated in an air furnace to an intense heat for three or four hours. The alloy contains about 25 per cent. of manganese, and rolls easily when cold. *See* Chemical News, Vol. XXII., p. 194.

2451. Alloy of manganese and chromium, containing 60 per cent. of the latter.

Prepared in the laboratory of the Royal School of Mines. It is white, granular, porous, and brittle.

2452. Alloy of manganese and chromium, containing 20 per cent. of the latter.

Prepared in the laboratory of the Royal School of Mines. It is a white mass, with occasional prismatic crystals, and mixed with green slag; a sample of the separated slag is contained in one tube, and some small metallic globules with a perfect crystalline cleavage in another.

2453. Alloy of manganese with 10 per cent. of chromium.

Prepared in the laboratory of the Royal School of Mines. A dark grey brittle metallic mass, with prismatic crystals, accompanied by numerous globules of the same.

2454. Alloy of manganese with copper and zinc, worked into a stamp.

Made at Evans and Askin's Works, Birmingham. Communicated by H. Wiggin. It is supposed to contain some nickel also. It has the colour of light brass.

2455. Alloy of iron and manganese or "ferro-manganese."

Two specimens, one containing 46 per cent. of manganese, the other about 50 per cent. They have been produced by heating manganic oxide and iron ore with lime and coal in Siemen's gas regenerator furnace at Terre Noire, St. Etienne, Loire, for the purpose of making spiegeleisen. They contain about 6 per cent. of carbon.

2456. Ferro-manganese, containing about 50 per cent. of manganese.

Made in a cupola from Italian ores. Communicated by H. E. Hackney. It contains about 5 per cent. of carbon.

2457. Ferro-manganese, containing about 50 per cent. of manganese.

Made in a Siemens' furnace from Italian ore. Communicated by H. E. Hackney.

2458. Alloy of one part of iron with two of manganese.

It has the fracture of a very fine grained white iron. It contains 67 per cent. of manganese, and is used at the North Woolwich Works for the manufacture of spiegeleisen. Communicated by G. W. Harvey.

2459. Results of experiments on the combination of manganese and copper.

NICKEL.

ORES OF THE METAL.

2460. Kupfernickel from Schneeberg, Saxony.

Called "Rothnickelkies." The kupfernickel or arsenide of nickel is imbedded in isolated grains in the midst of quartz vein-stuff.

2461. Kupfernickel from the Kupferschiefer of Mohringen, near Sangershausen, Saxony.

The ore occurs in an irregular breccia.

2462. Kupfernickel from Linares, Spain.

A small green-coated mass. Contains 43·85 per cent. of nickel.

2463. Kupfernickel as imported.

Used at the Nickel Works of Messrs. Evans and Askin, Birmingham.

2464. Rough kupfernickel coated with green.

The green coating is probably nickel ochre.

2465. Grey nickel ore.

Contains kupfernickel disseminated through it. It is this that is called false copper ore, as it yields no copper.

2466. Copper nickel ore.

From the mines of Mr. Ascham at Lessebo, Sweden. Contains mixed sulphides of copper and nickel, and yields on smelting an alloy of the two metals containing 80 per cent. of nickel. *See* No. **2550.**

2467. Nickel ore from the United States of America.

As imported for the Nickel Works of Evans and Askin, Birmingham. It is probably from Connecticut, and consists of a green earthy mass, containing some salt of nickel.

2468. Nickel ore from the United States.

As imported for the Nickel Works of Evans and Askin, Birmingham. It is a nickeliferous pyrites containing lead and copper.

2469. Nickel ore.

As imported for the Nickel Works of Evans and Askin, Birmingham. A massive grey ore like mispickel, associated with copper pyrites. Probably nickel-glance.

2470. Nickeliferous pyrites from Espedal, Norway.

As imported for the Nickel Works of Evans and Askin, Birmingham. Kupfernickel and iron pyrites are about equally divided.

2471. Nickeliferous pyrites from Norway.

A brecciated mass with disseminated kupfernickel. A portion analysed yielded only 1·28 per cent. of nickel.

2472. Nickeliferous pyrites from Espedal, Norway.

Communicated by D. Forbes. A brecciated mass from a hornblendic rock impregnated with pyrites and kupfernickel.

2473. Nickel ore from New Caledonia.

Communicated by R. Daintree, 1876. A bright green earthy ore called garnierite or noumeite. It is a hydrated magnesian silicate, more or less impregnated with nickel oxide, and containing on an average 24 per cent. of nickel.

2474. Nickel ore from Inverary.

A disintegrating mass of nickeliferous pyrites. A sample of this ore, analysed by Greg and Lettsom, gave iron 43·76, nickel 14·22, sulphur 34·46, silica 5·90, and lime 1·45.

2475. Nickel ore ? from Lamerhoe Mine, Cornwall.

Probably a nickeliferous mispickel.

Speiss and Regulus obtained in the extraction of Nickel from the Ores.

2476. Crystallised nickel speiss.

From Espedal, Norway. Communicated by D. Forbes. A yellowish granular mass with cavities towards the surface, which has crystallised in jagged crests. This contains the nickel of the ore, combined with the arsenic and sulphur, but freed from most of the other ingredients.

2477. Crystallised matt and speiss of nickel.

From Espedal, Norway. Communicated by D. Forbes. In this specimen the lower portion contains most of the sulphur, in combination with various substances, and the upper portion most of the arsenic in combination with the nickel. This, like No. **2476,** runs out into jagged crystalline crests on the surface.

2478. Nickel speiss.

As produced at Evans and Askin's Nickel Works, Birmingham. A solid mass with crystalline cleavage, and the colour of kupfernickel.

2479. Nickel sulphides.

As produced with the speiss at Evans and Askin's Nickel Works, Birmingham. A finely porous pyritous mass of the colour of nickel sulphide.

2480. Nickel regulus.

A compact tarnished mass, light yellow when fresh, containing 41·94 per cent. of nickel, 19·75 per cent. of copper, in combination with sulphur, together with 1·09 per cent. of oxide of cobalt.

2481. Nickel regulus smelted at Piedmont.

This is afterwards sent to Liege for the extraction of the metal from it. A completely tarnished mass, but pale yellow on a fresh fracture. Compact between the scattered pores.

2482. Metal Nickel speiss.

Produced in the Nickel Works of Evans and Askin, Birmingham. It contains, at least, two distinct compounds coarsely intermixed; one is of the ordinary colour of kupfernickel, with irregular fracture; the other is bright grey, with crystalline cleavage.

2483. Nickel regulus.

Produced at Birmingham. It has been fused under charcoal, by which means the lead contained in it has gone as a button to the bottom. The remainder has been analysed by R. Smith, and found to contain 1·99 per cent. of copper, 9·2 per cent. of nickel, and 2·72 per cent. of oxide of cobalt. It is heavy brass-yellow, with a sub-crystalline fracture.

2484. Nickel regulus.

From the Nickel Works of Evans and Askin, Birmingham. It has been analysed by R. Smith, and contains 5·29 per cent. of nickel, and 4·12 per cent. of copper. These analysed specimens of regulus illustrate, by their poor per-centage of nickel, the concentration of the metal into the speiss.

2485. Nickel regulus.

Another sample of the same kind as the last. This contains, on analysis, 6·48 per cent. of nickel, and 6·27 per cent. of copper.

2486. Rich nickel speiss.

Porous, and very metallic in appearance. Formerly sold as nickel.

SLAGS PRODUCED IN THE EXTRACTION OF NICKEL.

2487. Blast furnace slags, from Espedal, Norway.

Communicated by D. Forbes. These are dark, and one has numerous large holes. They are composed of minute translucent crystals, having the appearance of some basic silicate.

2488. Crystallised slag, from the smelting of nickel ores in a reverberatory furnace.

Communicated by D. Forbes. The surface is covered by upstanding, translucent, plate-like crystals of olive-brown colour. They are slightly oblique. Probably an iron silicate allied to olivine.

2489. Crystallised slag, from melting nickeliferous iron pyrites in a blast furnace with coke.

From Espedal Works, Norway. Communicated by D. Forbes.

2490. Nickel slags.

From Barkis's Works. Produced in the reverberatory furnace. Some show numerous spherulites imbedded in a black glass.

2491. Crystalline slag produced in the smelting of Norwegian nickeliferous pyrites with lime, at Evans and Askin's Nickel Works, Birmingham, 1846.

In a cavity are seen numerous brilliant black octahedral crystals built up so as to be hopper-shaped on each face. Probably consisting of a silicate of iron.

2492. Another specimen from the same source.

This is scoriaceous on one side, and on the other has long light-coloured needle-like crystals, which are only isolated in the drusy cavities.

2493. Another specimen from the same source.

This is a drusy cavity in the centre of a compact slag at the boundary of two varieties of No. **2491.** It consists of innumerable small brilliant octahedra of iron silicate, with hopper-shaped faces, arranged parallel, so as to build up between them a much larger octahedron.

2494. Crystalline surface of nickel slag produced at the Nickel Works of Evans and Askin, Birmingham.

The compact side has numerous tears of melted slag, which indicate that this was the upper or exposed side; the crystal-covered surface must be a cavity of separation. It is clothed with a mass of small crystals, some of which are octahedra, like No. **2491,** but not so bright, and sometimes combined with the rhombic dodecahedron; others are the slender needles of No. **2492,** so that in this the two kinds of slag are combined.

2495. Slag from the smelting of nickel and cobalt ores.

Produced at the Nickel works of Evans and Askin, Birmingham. It is an opaque, indigo-coloured glass, which becomes black on the surface. The presence of cobalt indicates that this is a kind of smalt, the nickel being left behind.

FURNACE BOTTOMS AND BYE PRODUCTS.

2496. Crystallised nickel regulus from a furnace bottom.

Espedal Nickel Works. Communicated by D. Forbes. It has a dull brown, arborescent, crystalline surface.

2497. Crystallised basic sulphates from a furnace bottom.

Espedal Nickel Works, Norway. Communicated by D. Forbes. A coating of crystals lining a cavity in the slag. Sharp pointed, arborescent forms with rounded outgrowths, now black.

2498. The material used for the blast furnaces at Espedal.

Consists of ordinary mica schist.

2499. Gneissose rock used for the bottoms of blast furnaces at Espedal, Norway.

2500. The rock from the bottom of a Nickel furnace at Espedal.

This was similar to the last, but has now some thin films of metal run in between the bands. Communicated by D. Forbes.

2501. Rock from the bottom of a Nickel furnace, Espedal.

This was originally a light porous soapstone. It is now thoroughly impregnated with the sulphide of nickel which has settled to the bottom of the furnace on smelting the ore. Communicated by D. Forbes.

2502. Mass of sulphide of iron, showing crystalline cleavage surfaces.

Communicated by D. Forbes. From the Nickel furnaces of Espedal, Norway.

2503. Miscellaneous specimens from the Nickel Works of Espedal, Norway.

Communicated by D. Forbes.

2504. Sulphur obtained from the roasting heaps at the Nickel Works of Espedal, Norway.

Communicated by D. Forbes.

2505. Residue from the anode in a nickel plating battery.

A thin cake of greenish-black crystalline particles.

2506. Crystallised nickel vitriol.

Obtained by dissolving the roasted Norwegian nickel ore in hydrochloric acid. The sulphuric acid is doubtless produced by the roasting of the sulphides and re-acts on the metal dissolved by the hydrochloric acid. These crystals are not solid, but consist of a number of superimposed shells, with interspaces. They have the form of an oblique rhomb, and are greenish-yellow, with an external purple appearance. Long oblique acicular prismatic crystals are associated with them. From Evans and Askin's Nickel Works, Birmingham.

2507. Arseniate of iron precipitated in the extraction of nickel.

This is produced at the Nickel Works of Evans and Askin, Birmingham, by treating the roasted speiss with hydrochloric acid, and precipitating the arseniate of iron, at the common temperature, by lime water and chloride of lime. It is called "mud" by the workmen.

2508. Compound of cobalt produced in Nickel works.

This is called "bran" by the workmen. It is in coarse grains of flat shape, some red, some grey. From Evans and Askin's Works, Birmingham.

Various forms of the Metal.

2509. Hydroxide of nickel.

Communicated by Mr. Merry (1840), as "Crude nickel." Produced in the process of nickel extraction in the wet way, after separation of the iron and copper.

2510. Nickel in powder.

Communicated by Mr. Merry (1840). A fine, dark grey, loose powder by reduction of the oxide.

2511. Crude nickel.

Communicated by Evans and Askin, Birmingham. In small black scoriaceous lumps, mixed with charcoal, used in the reduction.

2512. Fine nickel.

Communicated by Mr. Merry (1840). Small irregular grey granules, showing here and there a green salt on the surface.

2513. Sample of impure nickel.

Communicated by Mr. Johnson.

2514. Crude nickel in lumps.

Communicated by Mr. Merry (1840). This is the solid metal which has been remelted from the granular form. It is slightly scoriaceous on the surface and is tinged with green.

2515. Crude nickel in various pieces.

Communicated by R. Phillips. The powder has been melted into some scoriaceous lumps, which are very porous.

2516. Crude nickel.

Communicated by Mr. Ekman. Several pieces fused together as for purification.

2517. Metallic nickel.

The oxide is worked into small cubes, which are then reduced by heating in charcoal. The forms of these cubes are seen here; some part has also been reduced in hydrogen.

2518. Fine nickel of foreign manufacture.

Communicated by Mr. Merry (1840). Probably from Saxony. These are the original masses reduced from the oxide.

2519. A button of nickel weighing 1,688 grains.

Obtained by fusing about 300 grains of nickel oxide with metallic nickel under glass, some of which still adheres to it.

2520. A mass of pure nickel.

Communicated by Mr. Askin. This specimen has been experimented upon by Faraday. With regard to its magnetic properties, *see* Phil. Mag., 1845. The fracture is extremely crystalline, showing fine arborescent forms throughout.

2521. Specimen of the first nickel made by a dry process from noumeite at Noumea.

Communicated by Prof. Liversidge in 1877. This is obtained from the new source of nickel, noumeite being a dark green, unctuous mineral consisting of a hydrated nickel and magnesian silicate, found chiefly in antipodeal regions.

2522. Imported granulated nickel.

Contains 98·1 per cent. of the pure metal.

2523. Refined nickel in fragments produced in Birmingham.

Contains 96·11 per cent. of the pure metal. Analysed by W. J. Ward.

2524. Nickel cast into the form of a horse-shoe magnet and keeper.

It does not show any perceptible magnetic properties by the ordinary tests.

2525. Bar of nickel said to be free from carbon.

Communicated by W. W. Wiggin, Birmingham, in 1882. Weight 17 ounces, of a brilliant white colour. The method employed to free the nickel from carbon is to resmelt it with a suitable proportion of oxide of nickel to burn off the carbon.

2526. Rolled sheet of nickel.

Communicated by W. W. Wiggin, Birmingham, in 1882. This is chiefly used in plating purposes, for which it is far superior to cast nickel.

2527. Nickel electro-deposited on sheet copper.

Communicated by J. H. Henry.

2528. Brass plated with metallic nickel.

Communicated by J. H. Henry.

2529. Nickel electro-deposited on sheet iron.

Communicated by J. H. Henry. It has not adhered in a satisfactory manner.

2530. Sample of nickel prepared for use in the manufacture of German coinage.

Prepared by H. Wiggin and Co., Birmingham, 1875. Contains 98·16 per cent. of pure nickel. Analysed by W. J. Ward.

2531. Ingot of pure nickel cast in sand.

By Brown, in October 1845, at Birmingham.

ALLOYS OF NICKEL.

2532. Samples of German silver of four qualities.

From Messrs. Evans and Askin's Nickel Works, Birmingham, 1845. No. 1 contains most nickel, viz., about 19 per cent. The zinc in this alloy is never added directly, but in the form of brass made by alloying equal parts of copper and zinc.

2533. Chinese Packfong.

This is the earliest known example of an alloy of nickel in use (except one ancient coin). The word signifies white copper, and analysis shows it to be composed of 4·4 per cent. of copper, 25·4 per cent. of zinc, 31·6 per cent. of nickel, and 2·6 per cent. of iron. This sample has been rolled out into sheets.

2534. Samples of German silver solder.

That is, of an alloy suitable for soldering German silver articles.

2535. German silver wires.

They are of considerable thickness, but both have split down the centre. Communicated by R. Clay, 1875.

2536. Alloy of German silver with 12 per cent. of tungsten.

This has been rolled out into sheets, on the surface of which are seen long dark lines, caused by the drawing out of the spots of the incompletely combined tungsten.

2537. German silver alloyed with 10·49 per cent. of tungsten.

Prepared by Dr. Percy in 1845.

2538. German silver alloyed with 4 per cent. of tungsten.

Formed by heating together 32 parts of an alloy composed of equal weights of copper and nickel with 24 parts of copper shot and 8 parts of metallic tungsten. *See* British Association Report, 1848.

2539. Alloy of German silver with 12·59 parts of tungsten, Prepared by Dr. Percy in 1845.

2540. Alloy of German silver and tungsten.

819 grains of the former have been melted with 200 grains of the latter. It has a dull yellowish tint.

2541. Alloy of German silver and tungsten containing 16·34 per cent. of the latter.

Prepared by Dr. Percy in 1845.

2542. Alloy of German silver and tungsten.

These have been polished, and show the speckly surface produced by incomplete union with the dull tungsten.

2543. Defective German silver, which will not braze, as it is fusible, probably owing to its containing manganese.

Communicated by R. Clay, 1877.

2544. Defective German silver of second quality, showing a blister on one side.

Communicated by R. Clay, 1877.

2545. Crystalline granular powder, said to consist of nickel and iron.

From the Swedish Department, Exhibition of 1862.

2546. Alloy of one part of nickel and one part of copper.

Cast in an ingot mould, 1845, by Evans and Askin, Birmingham. This scarcely shows the colour of the copper at all.

2547. Alloy of nickel and iron.

Communicated by H. Brookes & Co., 1879. It has a rough surface, a coarsely crystalline, arborescent fracture, and a yellowish colour.

2548. Alloy of nickel and iron from New Caledonia.

Melted and granulated by pouring into water, in order to obtain a good average for assay. Communicated by C. Tookey. The pieces are dark in colour, crystalline, and rather scoriaceous within.

2549. Portion of nickel and iron (with silicon and carbon) alloy.

Smelted from noumeite or garnierite in New Caledonia. Communicated by C. Tookey, 1882. It is run down in a furnace with limestone and fuel, and cast into ingots and cakes, which are then sent to Sydney, instead of importing the ore, which may contain no more than 15 per cent. of nickel. The average per-centage of nickel in the alloy is 70 per cent. This piece is a portion of a sample which solidified in the pot. It is dark grey in colour, and has a rough fracture and only slightly in recognisable crystals and is somewhat scoriaceous.

2550. Alloy of nickel and copper.

Derived from the mines and works of Mr. Ascham at Lessebo, Sweden. Communicated by Mr. B. Donkin. It contains 16·76 per cent. of copper, 80·42 per cent. of nickel, 2·30 per cent. of iron, and 0·76 per cent. of sulphur. Analysed in 1853.

2551. Alloy of nickel with 5 per cent. of tin.

Experiment by Dr. Percy at Evans and Askin's Nickel Works, Birmingham, in 1845. It has bent before breaking, and has a granular fracture.

2552. "Pottery nickel."

An impure compound of nickel and arsenic, of yellow metallic appearance, resembling Kupfernickel, to which it corresponds in general composition.

2553. Alloy of copper and nickel.

Manufactured in Birmingham, in small cubes of rather open granular structure within. They contain 91·54 per cent. of nickel and 4·93 per cent. of copper.

2554. Swiss coinage of 1850 containing nickel.

The amount of nickel is said to be 20 per cent., the metals alloyed with it being silver, copper, and zinc.

2555. Sample French coin, not in currency, made of nickel from New Caledonia, 1881.

On the opposite side are written the words "Specimen 'le Nickel,' all. 25·75, Société anonyme." This is an attempt to introduce a 5 cent. piece of this composition under the name of a "Nickel."

COBALT.

THE ORES OF COBALT.

2556. Arsenical cobalt or Skutterudite.

Small metallic iridescent crystals, of various combinations of the cubic system. From Skutterude, near Modum, Norway. Contains 20 per cent. of cobalt.

2557. Cobalt ore as imported from America.

Used in Evans and Askin's Works, Birmingham, 1845. In the form of an earthy, dark brown powder. Probably from Mine la Motte, Missouri.

2558. Cobalt ore with manganese, as imported from America.

Used in Evans and Askin's Works, Birmingham, 1845. An earthy, brown powder. The ore commonly called earthy cobalt, being a hydrated oxide of cobalt and manganese.

2559. Cobalt ore with manganese, from Australia.

This consists of compact, bluish-black stalactitic, and branching masses, contained within boundaries of quartz. Probably a psilomelane with cobalt oxide. Analysed by W. J. Ward in 1867.

2560. Cobalt ore, from Africa.

Communicated by Mr. Whitehead.

2561. Arseniate of cobalt, or cobalt bloom, from South Africa.

Communicated by the South African Mining Company. Analysed by R. Smith, 1875. Contains 22 per cent. of oxide of cobalt, and 2 per cent. of nickel. Consists of bands of fibrous purple crystals, impregnating sand.

2562. Smaltine, from Africa.

Communicated by the South African Mining Company. Analysed by R. Smith, 1875. Contains 18·97 per cent. of cobalt and 2·58 of nickel. It is an arsenide of cobalt and nickel. Tin white, but tarnishes pink.

2563. Cobalt ore, from South Africa, north of the diamond fields.

Communicated by Mr. P. Whitehead. Analysed by R. Smith, 1873. Contains 19·45 per cent. of oxide of cobalt. A pink, earthy bloom.

2564. Cobalt ore, from New Caledonia.

Communicated by Mr. D. Dixon. Analysed by R. Smith, 1876. Contains 3·87 per cent. of oxide of cobalt, and also chrome-iron. It is black and earthy.

PREPARATION OF COBALT.

2565. Zaffre.

The product of roasting the arsenical ores or cobalt speiss, which yield an arseniate of cobalt. Analysed by W. J. Ward. Contains 13·44 per cent. of oxide of nickel and 38·43 per cent. of oxide of cobalt.

2566. Cobalt and nickel speiss.

Contains also sulphide of molybdenum. A black metallic-looking mass, obtained by fusing the ore with a flux to carry away the iron, &c.

2567. Residue from copper works at Alderley, containing cobalt and manganese.

The copper and iron in the Triassic sandstone at Alderley is extracted by acid, and these are afterwards separated, and this residuum is left. It is a black mass of powder resembling wad in appearance, which mineral occurs native in the same locality.

2568. Furnace accretion from cobalt furnaces, Pfannenstiel.

Communicated by Mr. Blandford. A yellow, green, and purple bloom.

2569. Concretion from the base of a cobalt and nickel furnace.

At Evans and Askin's Works, Birmingham, Gibbs and Canning's highly pyritous coal being used in the smelting. A pink-coloured stalactitic slag.

THE REDUCED METAL.

2570. Impure metallic cobalt.

Communicated by H. Wiggin. Produced at Evans and Askin's Works, Birmingham, 1867. Contains fragments of the glass under which it has been smelted. The surface has numerous circular pits, as from the escape of gas.

2571. Two specimens of metallic cobalt.

Prepared by Mr. Askin in 1845. One of these is fractured, and shows a coarse, crystalline, arborescent fracture. The other, which encloses portions of the glass beneath which it has been fused, has a very regular radial crystallisation on its upper flat surface, and is irregular in the centre. On one of these specimens Faraday determined the magnetism of cobalt. *See* Phil. Mag., 1845.

2572. Pure cobalt.

Prepared by Emile Rousseau, of Paris. Small spongy pieces, or foil-like, and brilliantly white.

LIBRARY OF THE UNIVERSITY

2573. A sheet of rolled cobalt.

Produced and communicated by Mr. W. Wiggin, at Evans and Askin's Cobalt and Nickel Works, Birmingham, 1882. A beautifully smooth and uniform sheet, of great hardness, not easily scratched by steel.

COMPOUNDS OF COBALT.

2574. Glass coloured blue by oxide of cobalt.

This was the original form in which cobalt was used before it was ascertained that the blue colour was due to the oxide of an hitherto undiscovered metal.

2575. Fine smalts.

The original commercial product of cobalt. It is the blue glass powdered for mixing as a paint.

2576. Silicate of cobalt.

Prepared at the Works of Evans and Askin, Birmingham. A purple scoriaceous mass, very different from smalt glass, which is not an actual compound of cobalt.

IRON AND STEEL.

EXPERIMENTS ON THE CHARACTERS AND COMPOUNDS OF IRON.

2577. Supposed pure iron, by Berzelius' process.

Iron filings mixed with $\frac{1}{5}$ their weight of ferric oxide are heated for an hour under pounded glass free from metallic impurities, in a covered Hessian crucible with coke. The fracture is largely crystalline and greyish white, and the mass has a specific gravity of 7·8707. A portion of it has been hammered and rolled in the cold; the specific gravity of this is 7·865; but it is not really pure, as it evolves fetid hydrogen when treated with hydrochloric acid. *See* Percy's Metallurgy, Iron and Steel, p. 1.

2578. Electro-deposited iron, subjected to experiments.

This iron is deposited on copper plates for the purpose of protecting them. The liquid used in this process, which is known as aciérage, is a solution of ferrous chloride and chloride of ammonium. The bright polish is original in the thin films. This iron does not give any fetid smell when heated in hydrochloric acid. The specimens experimented upon have, however, rusted rapidly in the moist air. The specific gravity of these has been determined in six experiments by R. Smith, the most trustworthy of which gave 8·1393. Some have been plunged, while red hot, into mercury, without losing their hardness or flexibility. Other specimens show the finest film, and the amount deposited in 24 hours. *See* Percy's Metallurgy, Iron and Steel, p. 2.

2579. Pyrophoric iron in powder.

Pure ferric oxide was prepared by the addition of ammonia in excess to a solution of ferric chloride, and the precipitated mass was reduced by purified hydrogen under a gentle heat. The reduced metal in powder, when shaken into the air from the tube, spontaneously ignited, and was made to do so again by heating it to about 100° C.

2580. Series of samples of "burnt iron" expressly made at the Dowlais Ironworks, Wales.

There are 10 specimens, two of which has been forged into smaller bars. They have a largely crystalline and irregular fibrous fracture, with dark patches. They are supposed to be unforgable, but the specimen marked W has been forged into a rod with a good fibrous fracture, and one marked A into one less fibrous. Communicated and prepared by E. Riley. *See* Percy's Metallurgy, Iron and Steel, p. 7.

2581. Iron vessel made for experiments on the permeation of hydrogen when acted on by dilute sulphuric acid.

2582. Reduction of ferric oxide by heating in hydrogen.

Powdered hæmatite has been heated in a gas furnace in hydrogen. The first stage of the reduction, in which it has become magnetic oxide, is here shown. *See* Percy's Metallurgy, Iron and Steel, p. 17.

2583. Compound of ferric oxide and lime, produced artificially.

An intimate mixture of 190 grains of ferric oxide and 66·5 grains of lime were kept heated to whiteness for several hours in a platinum crucible, by means of a muffle furnace whose atmosphere is oxidizing, and there left to cool. The product consists of dark lustrous acicular crystals, which are magnetic and have a specific gravity of 4·693. Analysed by R. Smith.

Ferric oxide - - - -	73·39
Ferrous oxide - - -	0·72
Lime - - - -	24·50
Silica - - - -	1·35
Alumina - - - -	0·10
	100·06

See Percy's Metallurgy, Fuel, 1875, p. 78 ; cf. Iron and Steel, p .19, and Phil. Mag., Series 4, 1873, XLV., p. 455.

2584. Experiment on the union of lime and hæmatite.

Hæmatite strongly heated in a lime crucible. Only a few dark masses are formed.

2585. Further experiment on the union of lime and hæmatite.

A mixture of one equivalent of lime to one of hæmatite strongly heated in a lime crucible. More numerous dark masses are formed.

2586. Magnetite artificially formed in the extraction of iodine from Chilian nitre.

Cast iron retorts are used for the subliming, and the surface becomes coated with crystalline magnetite.

2587. Pure ferric oxide.

Obtained from ferrous sulphate by means of alcohol and nitric acid. Precipitated by ammonia and washed free from sulphuric acid.

2588. Magnetic oxide of iron, formed from the hard ore of the Hæmatite Iron Co.

It contains 15·25 per cent. of silica.

2589. Action of sulphur on iron.

A strip of sheet iron has been left in an aqueous solution of hyposulphite of soda. It has become quite black, and the powder has been shown by the evolution of sulphuretted hydrogen when treated with hydrochloric acid to be sulphide of iron.

2590. Sulphide of iron, produced by heating together zinc sulphide and iron filings.

The iron sulphide has been found to be free from zinc.

2591. Result of an experiment on the combination of iron and sulphur.

The resulting mass is of metallic appearance, and the same has been remelted into globules.

2592. The graphite and slag produced in the above experiment.

2593. Globules of iron separated from the graphite produced in the above experiment.

2594. Solution of sulphide of iron in molten iron.

The sulphide was prepared by heating together sheet iron and sulphur, and was found to contain 29·9 per cent. of sulphur. 960 grains of this sulphide were melted with 1,920 grains of iron wire, under plate glass in a clay crucible. The product is highly crystalline and homogeneous, and has a black vitreous slag above it. *See* Percy's Metallurgy, Iron and Steel, p. 33.

2595. Solution of sulphide of iron in molten iron. Second experiment.

1,440 grains of the same sulphide were heated with an equal quantity of iron wire. The product is well melted and was covered with black slag, but is less crystalline than the last. These experiments show that sulphide of iron dissolves in iron in very variable proportions. *See* Percy's Metallurgy, Iron and Steel, p. 33.

2596. Result of fusing two equivalents of galena with one of ferrous sulphide.

The mixture was melted under charcoal, stirred with a piece of wood, and slowly cooled. It consists of two tolerably distinct layers; an upper one crystalline and like galena in colour, and a lower one more largely crystalline, rather darker in colour, and with less lustre. *See* Percy's Metallurgy, Iron and Steel, p. 37.

2597. Result of fusing one equivalent of galena with one of ferrous sulphide.

The mixture was melted under borax. The product is a dark bluish-grey crystalline mass, presenting no sign of separation into distinct layers. It had a black crystalline slag on its surface. *See* Percy's Metallurgy, Iron and Steel, p. 37.

2598. Result of fusing one equivalent of galena with two of ferrous sulphide.

The fusion was made as in the last experiment, and the resulting mass is dark grey and crystalline, equally homogeneous with the last. *See* Percy's Metallurgy, Iron and Steel, p. 38.

2599. Iron wire which has been heated in ammonia.

One portion of this, in which the heating only lasted 1¼ hours, has increased in weight from 254·17 grains to 255·30 grains. A piece of it was dissolved in hydrochloric acid, and the solution distinctly evolved ammonia on addition of excess of potash. *See* Percy's Metallurgy, Iron and Steel, p. 55.

2600. Thick iron wire heated in ammonia.

This increased in weight from 302·03 grains to 302·60 grains. It is only superficially changed, the altered portion, which was attracted by the magnet, having scaled off on bending.

2601. The lowest phosphide of iron.

This is prepared by directly uniting the two elements by dropping bits of phosphorus on iron filings heated to redness in a crucible, with the least possible access of air. The product has its upper surface covered with interlacing crystals, which occur also in cavities in the interior. They consist of tetragonal prisms. The fracture is very uneven and confusedly crystalline. The colour is white. It is nearly as hard as felspar and has a specific gravity of 7·245. Analysis by W. J. Ward has shown that it contains 11·02 per cent. of phosphorus. *See* full description, with the reactions, in Percy's Metallurgy, Iron and Steel, p. 60.

2602. Iron containing 1 per cent. of phosphorus.

Prepared by melting fine iron wire with iron phosphide. It is harder, whiter, and more brittle than a similar button of iron free from phosphorus. Experiment by W. Hochstätter. *See* Percy's Metallurgy, Iron and Steel, p. 64.

2603. Result of heating iron with iron phosphate.

Three parts, by weight, of "phosphate of protoxide of iron" were heated with four parts of iron filings. The resulting button contains 2·38 per cent. of phosphorus, and has very similar properties to that with 1 per cent. Experiment by W. Hochstätter. *See* Percy's Metallurgy, Iron and Steel, p. 69.

2604. Compound of iron and arsenic approximating to the formula Fe_2As.

Pieces of hoop iron were heated to whiteness in a clay crucible, and then an excess of arsenic was dropped in. The product was again heated to whiteness for about an hour in clay crucibles with luted covers. It now contains 57·74 per cent. of iron, and is close grained and crystalline in fracture. *See* Percy's Metallurgy, Iron and Steel, p. 75.

2605. Compound of iron and arsenic approximating to the formula $Fe_3 As$.

Of the two specimens, one was obtained from an auriferous ore composed of iron pyrites, arsenical pyrites, &c., by fusion with borax, carbonate of soda, red lead, and charcoal, and stirring with an iron rod. It contains 28·89 per cent. of arsenic to 70·93 per cent. of iron. The other was obtained from arsenical galena, by fusion with carbonate of soda, and inserting a piece of hoop iron. It contains 27·18 per cent. of arsenic to 72·17 per cent. of iron. *See* Percy's Metallurgy, Iron and Steel, p. 76.

2606. Cannon ball, containing arsenic.

Purchased as old iron at Sinope, in Greece, which was attacked by the Russian fleet in 1854. The fractured surface has a radiated, crystalline structure. It has a greyish-white colour like white-iron, and several cavities, due to bad casting. Borings from a similar ball have been analysed by Dr. Noad, and gave 16·20 per cent. of arsenic and only 0·57 per cent. of sulphur, and mere traces of silica and phosphorus. Communicated by Mr. Levich, of the Blaina Ironworks, 1859. *See* Percy's Metallurgy, Iron and Steel, p. 76.

2607. Piece of "puddled bar" made from the above balls?

It has a glistening, highly crystalline fracture and will not weld. *See* Percy's Metallurgy, Iron and Steel, p. 77.

2608. Attempt at the production of a silicide of iron by means of silico-fluoride of potassium.

900 grains of this were heated with 450 grains of iron wire cut into short pieces, but no silicon is found to pass into the iron. *See* Percy's Metallurgy, Iron and Steel, p. 91.

2609. Another experiment with the same object.

2610. Attempt at the production of a silicide of iron by means of hydrofluo-silicic acid.

The dry gas was passed over this coil of iron wire in a porcelain tube heated beyond redness, but it remained unchanged. *See* Percy's Metallurgy, Iron and Steel, p. 92.

2611. Siliciferous iron, produced by the aid of charcoal.

Pure iron wire has been imbedded in fine white sand and charcoal, and exposed to an intense heat in a closed crucible. Experiment by R. Smith.

2612. Silicide of iron by reduction of silica.

2,000 grains of a pure variety of red hæmatite, containing about 69 per cent. of iron, was intimately mixed with 2,310 grains of fine sand and 900 grains of charcoal, and heated in a covered crucible to a high temperature during 1½ hour. Magnetic particles were extracted from the product and fused alone. A well melted button, weighing 961 grains, has thus been obtained. It is hard and brittle and minutely crystalline. It has a specific gravity of 6·94, and contains 12·26 of silicon per cent. Experiment by W. Hochstätter, 1863. *See* Percy's Metallurgy, Iron and Steel, p. 92.

2613. Silicide of iron by reduction of silica.

6,000 grains of the same red hæmatite were mixed with 4,000 grains of the sand and 2,700 grains of charcoal, and treated in the same way. The resulting button is brighter in fracture and lighter in colour. It weighs 1,945 grains, has a specific gravity of 7·23, and contains 8·96 per cent. of silicon. In both cases it is believed that carbon is present. *See* Percy's Metallurgy, Iron and Steel, p. 92.

Results of a series of experiments conducted by R. Smith on the production of silicified iron from hard red hæmatite containing much finely diffused quartz.

This ore left on digestion with hydrochloric acid an insoluble residue of 13·49 per cent., of which 12·76 per cent. consisted of silica. It was variously treated, and the resulting iron analysed by W. Weston, to show the per-centage of silicon introduced. For the account of these experiments, *see* Percy's Metallurgy, Iron and Steel, p. 93.

2614. Result of Experiment I.

1,000 grains of the hard ore were submitted to a very high temperature with 250 grains of charcoal. 601 grains of metal were produced, containing 0·87 per cent. of silicon.

2615. Result of Experiment II.

The hard ore was heated to a very high temperature with the charcoal in excess. The resulting metal contains 13·78 per cent. of silicon. The surface of the button is honeycombed.

2616. Result of Experiment IIA.

The hard ore was heated with an excess of charcoal and sand. The button of metal obtained contains 8·84 per cent of silicon. The surface of the button is quite smooth.

2617. Result of Experiment III.

1,000 grains of hard ore were heated with 250 grains of charcoal, 100 grains of lime, and 250 grains of fluor-spar. The resulting metal weighed 660 grains, and contained 1·41 per cent. of silicon.

2618. Result of Experiment IV.

1,000 grains of hard ore were heated with 250 grains of charcoal and 150 grains of fluor-spar. The result was 650 grains of iron, containing 2·15 per cent. of silicon, with 226 grains of slag.

2619. Result of Experiment V.

1,000 grains of hard ore were heated with 250 grains of anthracite, 190 grains of clay, and 110 grains of sand. The resulting metal contains 0·64 per cent. of silicon, and the composition of the accompanying slag is lime 51·08, alumina 9·7, silica 39·2.

2620. Result of Experiment VI.

1,000 grains of hard ore were heated with 250 grains of charcoal, 300 grains of lime, and 190 grains of sand. The resulting metal contains 0·58 per cent. of silicon. The accompanying slag has a per-centage composition of lime 52·4, alumina 13·3, and silica 34·3, thereby approaching closely the ordinary "blast furnace cinders."

2621. Result of Experiment VII.

1,000 grains of hard ore were heated with 250 grains of anthracite in powder, 125 grains of lime, 190 grains of clay, and 260 grains of sand. The resulting metal is white iron, and contains 0·85 per cent. of silicon. The reduction is not complete. [The description on the label and in the "Metallurgy" do not entirely agree.]

2622. Result of Experiment VIII.

1,000 grains of the hard ore were heated with 200 grains of anthracite, 125 grains of lime, 190 grains of clay, and 260 grains of sand; and the mixture was covered by a thin layer of anthracite powder. The resulting metal contains 0·38 per cent. of silicon, and the accompanying green slag has the per-centage composition of lime 19, alumina 11·55, silica 69·45.

2623. Result of Experiment IX.

1,000 grains of hard ore were heated with 250 grains of anthracite, 125 grains of lime, 190 grains of clay, 1,400 grains of sand; 50 additional grains of anthracite powder were placed on the top of the mixture. The resulting iron weighed 387 grains, and contains 1·15 per cent. of silicon. The accompanying slag is green.

2624. Result of an unrecorded experiment.

1,000 grains of the hard ore were heated with 250 grains of anthracite, 190 grains of clay, and 350 grains of lime. No proper button is formed, but a white stony slag, with scattered globules of metal.

2625. Result of another unrecorded experiment.

1,000 grains of the hard ore were heated with 250 grains of anthracite, 190 grains of clay, and 325 grains of lime. The result is a white scoriaceous stony slag, with numerous metallic globules.

2626. Wrought iron melted in 15 minutes from a $\frac{5}{16}$ square bar in a closed clay crucible.

2627. Attempt at the union of ferric oxide with alumina.

A mixture in the ratio of the equivalents was strongly heated in a platinum crucible. The result is a slightly coherent mass, without evidence of union. Experiment by R. Smith, 1871. The same mass reheated in a clay crucible has produced a black glassy substance.

2628. Attempt at the union of ferric oxide and lime.

A mixture in the ratio of the equivalents was strongly heated in a platinum crucible contained within a crucible of lime. A portion has run together into a black slag. The remainder is still in powder. Experiment by R. Smith, 1871.

2629. Attempt at the union of ferric oxide and lime.

A mixture in the ratio of the equivalents has been strongly heated, but only a certain amount of adhesion is brought about. Experiment by R. Smith, 1871.

2630. Micaceous oxide of iron produced artificially.

By heating crystals of sulphate of iron with salt, and washing the precipitate with water.

2631. Production of slag by the union of hæmatite and limestone.

160 grains of ferric oxide have been heated with 100 grains of carbonate of lime, and the product is a dark, opaque, slag-like mass.

2632. Result of experiment with a soft ore.

This ore contains only 6·36 per cent. of matter insoluble in hydrochloric acid, of which 1·87 per cent. is silica. This has been heated with excess of charcoal, and has yielded a metal containing 1·66 per cent. of silicon.

2633. Result of another experiment with the same ore.

It was fused with fine sand, and an excess of charcoal, and the metal produced contains 5·15 per cent. of silicon.

2634. Results of experiments on the production of silicides of iron.

By E. Riley. Dowlais Iron Works, 1871. A mixture of red hæmatite ore, with charcoal in excess, and siliceous sand, from crushed washed sandstone, was made and fused after exposure in a plumbago steel-pot in a Siemens' furnace for 36 hours. The fused mass of iron at the bottom (No. 1) was about 3 lbs. in weight. It contains 17·96 per cent. of silicon. Much of the sand retained its granular form, with fused cinder (No. 4) between the granules containing scattered buttons of iron (No. 3), which contain 3·72 per cent. of silicon. There are also many buttons suspended in the charcoal (No. 2), which contain 21·71 per cent. of silicon.

2635. Results of another experiment of the same kind.

In this case silicate of iron was first formed from the same red ore as above, by mixing it with sand and a little charcoal, after pulverising it, and mixing the whole with wood charcoal, and exposing it in a plumbago pot in a Siemens' furnace for 36 hours. Siliceous cinder (No. 6) was perfectly fused, and the mass of iron at the bottom (No. 5), which was about 4 lbs. in weight, is highly crystalline in fracture, with large graphitic scales, and contains 17·40 per cent. of silicon. Communicated by E. Riley.

2636. Result of experiment on the union of silicide of iron with phosphide of iron.

220 grains of silicide of iron, containing 8·96 per cent. of silicon, were mixed with 143 grains of phosphide of iron, containing 12·66 per cent. of phosphorus. The mixture was heated in a covered clay crucible placed within another, and heated during 1 hour to whiteness

The button produced weighed 356 grains, and had a little slag on the top. It is hard, brittle, and strongly magnetic. Its fracture is crystalline, but dull, and its colour light greyish-white. It contains 5·57 per cent. of silicon, and 4·50 per cent. of phosphorus. Experiment by Mr. Hochstätter. *See* Percy's Metallurgy, Iron and Steel, p. 95.

2637. "Silicate of protoxide of iron."

Prepared by W. B. Richardson. The proportions employed were hæmatite 47·1, silica 57·5, and anthracite 6 per cent. This mixture was heated to whiteness in an iron crucible. It is highly vesicular, dark olive brown in colour, opaque, brittle, and vitreous. It contains 33 per cent. of iron. *See* Percy's Metallurgy, Iron and Steel, p. 96.

2638. "Trisilicate of protoxide of iron."

Prepared by W. B. Richardson. 2,400 grains of hæmatite, 900 grains of pure white sand, and 180 grains of powdered anthracite being in the proportions of 78·1, 29·8, and 6 per cent. were treated in the same way as in the last experiment. The product weighed 3,070 grains, showing 70 grains to have been derived from the iron crucible. It has a bright almost metallic lustre, is brittle and crystalline, the cavities containing crystals of iron olivine. It contains 54 per cent. of iron. *See* Percy's Metallurgy, Iron and Steel, p. 96.

Results of a series of experiments on the carburisation of iron by cementation. Nos. **2639–2644.**

See Percy's Metallurgy, Iron and Steel, p. 105.

2639. Strips of iron prepared for experiments by means of hydrogen.

2640. Result of Experiment 4.

The strip of iron was imbedded in sugar charcoal and heated in a porcelain tube during two hours in a current of hydrogen, and allowed to cool in the gas. The charcoal had already been used in a similar experiment. The strip increased in weight from 15·385 to 15·550 grains.

2641. Result of Experiments 5 and 6.

The curved pieces were treated by imbedding one in the previously used charcoal and not the other, and passing hydrogen over them at a red heat. The free strip increased in weight from 5·405 grains to 5·425 grains. The imbedded strip increased from 5·805 grains to 5·850 grains. The free strip is more dead in lustre and the other is deeper grey. The unbent portions were treated in a similar way.

2642. Result of Experiment 9.

2643. Result of Experiment 10.

The strips were placed in two long glass tubes. In one the strip was imbedded in the same charcoal as used in previous experiments, and both were heated in hydrogen for three and a half hours. The free strip has increased in weight from 9·458 grains to 9·468 grains. The imbedded strip increased from 10·081 grains to 10·133 grains.

2644. Result of Experiment 11.

The last experiment was repeated with two free strips and electrotype iron, the hydrogen having been passed through nitrate of silver and over pumice wetted with sulphuric acid. The free strips have increased from 9·086 grains to 9·150 grains; the imbedded one from 5·026 grains to 5·080 grains.

2645. Experiment on the absorption of carbon by pure iron.

Conducted by R. Dick. Ferric oxide obtained from iron wire was intensely heated with excess of carbon. The result is a number of buttons and globules. The buttons have a specific gravity of 7·097. They split when hammered, and show plates of graphitic carbon, amounting in various trials to three or four per cent. *See* Percy's Metallurgy, Iron and Steel, p. 113.

2646. Another experiment on the same subject.

The ferric oxide was obtained from ferrous sulphate. The result is a multitude of small globules which will not fuse together on reheating. The largest button has a different fracture, a specific gravity of 6·968, and contains graphite to 4·56 per cent. *See* Percy's Metallurgy, Iron and Steel, p. 114.

2647. Mixture of grey and white cast iron.

The crystals of the white iron form a rectangular complex network, belonging to the cubical system, the sheets in a horizontal direction being the most conspicuous, with the grey iron in the interstices between them. Compare Percy's Metallurgy, Iron and Steel, p. 116.

2648. Experiment on the combination of iron with carbon.

Tin plate iron has been heated with chemically pure charcoal. The result is a very graphitic iron containing 4½ per cent. of carbon.

2649. Results of Messrs. Baker and Stuart's experiments on the conversion of soft iron into steel by means of carbonic oxide.

(*a.*) Specimen of a very soft iron used in the experiment. It is manufactured by Messrs. Marshall and Mills, Wednesbury. One of the pieces is straight, the other has been heated to a full red heat and quenched as in hardening steel; nevertheless, it remains perfectly soft and has been bent cold. (*b.*) Part of the same iron converted into steel by the action of carbonic oxide passed over at a full red heat for 12 hours. The carbonic oxide was prepared from oxalic acid and sulphuric acid. The evolved gas was passed through milk of lime, caustic potash, and pyrogallic acid, and dried by sulphuric acid. (*c.*) Another portion of the same steel broken in pieces to show its brittleness. The transverse section shows a central core of unconverted crystalline soft iron, surrounded by the fine grained steel, showing the depth to which the conversion has penetrated. Experiments conducted in 1864. Communicated by Wm. Baker. Compare Percy's Metallurgy, Iron and Steel, p. 105.

2650. Spiegeleisen melted under plate glass.

This does not show any separation of graphite or any sensible change in the external characters of the metal. *See* Percy's Metallurgy, Iron and Steel, p. 121.

Results of experiments on the action of sulphur on iron containing carbon conducted by W. Weston, recorded in Percy's Metallurgy, Iron and Steel, pp. 135, 136. Nos. **2651–2654.**

2651. Result of Experiment 7.

376 grains of cast iron were melted with 64·5 grains of iron sulphide, which is equivalent to introducing 4·378 per cent. of sulphur. The product is white iron, without graphite. It contains 2·12 per cent. of sulphur, showing a loss of 2·258 per cent. The carbon is 3·17 per cent.

2652. Result of Experiment 8.

359 grains of cast iron were melted with 29 grains of iron sulphide, which is equivalent to introducing 2·235 per cent. of sulphur, for half an hour. The button consists of very crystalline white iron, with separated graphite. The metal contains 1·68 per cent. of sulphur. The carbon amounts to 3·9 per cent., of which 1·44 per cent. is graphitic, the remainder being in combination.

2653. Result of Experiment 9.

415 grains of cast iron were melted with 18 grains of iron sulphide, which is equivalent to introducing 1·243 per cent. of sulphur. The product is white iron, with separated graphite. The analysis showed 1·313 per cent. of sulphur (which must be in error). The carbon amounts to 3·6 per cent.

2654. Result of Experiment 10.

302 grains of cast iron were melted with 7·2 of iron sulphide, which is equivalent to introducing 0·696 per cent. of sulphur. Some graphite separated. The metal is not white, but grey, with a network of white iron. The analysis showed 0·72 per cent. of sulphur (which must be in error).

2655. Result of experiment on heating grey pig-iron with sulphide of iron.

8,800 grains of grey pig-iron were melted in a clay crucible under plate glass with 870 grains of sulphide of iron containing 29·9 per cent. of sulphur. The metal here obtained has the appearance of white iron. It is brittle and excessively hard. The centre is more or less hollow, and shows a few skeleton crystals. The fracture is uneven and rather lamellar. It contains 0·78 per cent. of sulphur. Experiment by R. Smith, 1858. *See* Percy's Metallurgy, Iron and Steel, p. 133.

2656. Result of the action of sulphur on grey iron.

1,540 grains of grey pig-iron were melted with 90 grains of iron sulphide, equivalent to 2 per cent. The product is a hard white iron, with a somewhat lamellar fracture. It contains 0·78 per cent. of sulphur. Compare Percy's Metallurgy, Iron and Steel, p. 133.

2657. Grey pig-iron remelted.

2658. Result of experiment on the action of manganese containing carbon on iron containing silicon.

A very white metal is produced.

2659. Result of experiment on the heating of spiegeleisen containing manganese with ferric oxide.

2660. Formation of silicate of iron by the action of copper.

Six equivalents of copper, one of ferric oxide, and two of silica, were heated with abundance of charcoal, hæmatite being employed which contained the above proportion of silica. A union of the silica and iron has taken place. Experiment by R. Smith.

2661. The slag which accompanied the silicate of iron in the above experiment.

2662. Result of heating together 400 grains of roasted Wicklow pyrites, 15 grains of carbon, and 150 grains of silica.

The result is a pyritous button accompanied by an opaque blue glassy slag. Experiment by R. Smith.

2663. Result of an experiment on Wicklow pyrites.

3,500 grains of roasted ore, 131 grains of charcoal, 1,312 grains of silica, and 960 grains of cast iron have been smelted together. The products are (*a*) a light porous black shining slag, together with a minute particle of gold derived therefrom; (*b*) the button of iron left at the bottom; (*c*) a button obtained after treating part of the iron with lead; (*d*) minute particle of gold derived from the iron.

2664. Result of another experiment in heating grey pig-iron with sulphide of iron.

10,600 grains of another variety of grey pig-iron were melted during about an hour in a clay crucible, under plate glass, with 327 grains of sulphide of iron, containing 29·9 per cent. of sulphur. The metal produced contains 0·91 per cent. of sulphur, showing a loss of 0·815 per cent. The surface is coated with dark glass. A cut surface shows a mottled network of bright crystalline meshes. Experiment by R. Smith, 1858. *See* Percy's Metallurgy, Iron and Steel, p. 134, exp. 4.

ALLOYS OF IRON.

2665. Experiment on the fusion of spiegeleisen and copper.

500 grains of each have been fused together, showing a loss of 3·4 per cent. The product consists of copper below and spiegeleisen above, but the copper contains 1·18 per cent. of manganese and 3·19 per cent. of iron. Experiment by J. Richardson.

2666. Another experiment on the same subject.

666·45 parts of iron have been melted with 334 parts of copper. The loss on fusion has been 2·35 per cent., and the copper surrounds the iron with a dark intermediate layer between. Experiment by J. Richardson.

2667. Alloy of 10 of copper with 2 of iron.

200 grains of iron wire with 1,000 grains of electrotype copper were fused under plate glass, in a clay crucible, with luted cover. The result is a well melted button, showing a loss of 8 grains. It is much harder than copper, but the fracture is copper-red in colour. It has a granular fracture, but cannot be drawn into wire. Experiment by J. Richardson. *See* Percy's Metallurgy, Iron and Steel, p. 149.

2668. Alloy of 10 of copper with 3 of iron.

300 grains of iron and 1,000 grains of copper were heated together at a red heat. 55 grains of iron remained unfused, and the button has a paler colour, but is not so tough. It appears to be homogeneous, and contains 20 per cent. of copper. Experiment by J. Richardson. *See* Percy's Metallurgy, Iron and Steel, p. 149.

2669. Alloy of 5 of copper with 7 of iron.

500 grains of copper and 700 grains of iron were melted together as before. The button is well melted with a loss of 6 grains. The surface of the alloy is grey, like iron, and appears to be coated with it; it is crystalline and brittle, having minute crystal faces. It contains 58¼ per cent. of iron. Experiment by J. Richardson. *See* Percy's Metallurgy, Iron and Steel, p. 150.

2670. Alloy of 2 of copper with 8 of iron.

800 grains of iron and 200 grains of copper were melted together as before; the button was well melted with a loss of only 2 grains. It is extremely brittle. It has a pale coppery grey colour, and is crystalline granular. The fracture shows iron-grey mica-like scales, intermingled with copper-red particles. It contains 80 per cent. of iron. Experiment by J. Richardson. *See* Percy's Metallurgy, Iron and Steel, p. 140.

2671. Alloy of iron and manganese.

Made by G. Parry, Ebbw Vale Iron Works. It has a coarsely crystalline fracture, is greyish white, and is said to contain about 20 per cent. of manganese.

2672. Alloy of iron and manganese.

Obtained by reducing together hæmatite and pyrolusite. It probably contains carbon derived from the reducing agent.

2673. Alloy of iron and manganese.

Obtained by melting together spiegeleisen, which already contains some manganese and carbon, with pyrolusite to increase the proportion of manganese.

2674. Alloy of iron and manganese, and containing carbon.

2675. Ferromanganese crystals.

Made under the direction of Mons. Th. Gautier, in Wales, at the Pyle Company's Works, 1885. It is a loose aggregation of small crystals, some of which are acicular and iridescent. They contain 86 per cent. of manganese.

2676. Alloy of iron and tin.

490 grains of iron have been melted with 10 grains of tin, producing an alloy containing 2 per cent. of tin. The resulting button is brittle, being cracked in several places.

2677. Attempt at the union of iron and titanium.

125 grains of prepared ferric oxide and 127 grains of rutile were exposed in a covered brasqued crucible during 1½ hours, to a white heat, and reheated with 40 grains of lime and 60 grains of glass. Some grey globules are produced, but these, on analysis, do not show a trace of titanium.

2678. Alloy of titanium and iron.

A piece of rolled sheet iron, made direct from ilmenite, containing 45 per cent. of titanic acid, the remainder being iron oxides and only half per cent. of lime and magnesia. The whole of the metal was reduced. It contains the two elements in probably about equal proportions. Communicated by J. D. Clure, of Handsworth, 1875.

2679. Alloy of iron and antimony.

It contains 70 per cent. of antimony and 30 per cent. of iron. It is a porous ingot, tarnished on the fracture.

2680. Attempt at the union of iron and bismuth.

50 grains of bismuth have been melted together with 150 grains of iron. The bismuth has been for the most part eliminated, the resulting metal containing only 2·23 per cent. of bismuth.

2681. Union of iron and bismuth.

290 grains of iron have been fused with 10 grains of bismuth, under glass. The resulting button shows a loss of one grain only. Experiment by W. B. Richardson.

2682. Alloy of iron with 1 per cent. of nickel.

495 grains of iron were melted, under glass, with five grains of nickel. A well melted button has been obtained, weighing 490 grains. The fracture is like that of iron alone. Experiment by W. B. Richardson. *See* Percy's Metallurgy, Iron and Steel, p. 171, No. 1.

2683. Alloy of iron with 5 per cent. of nickel.

285 grains of iron were melted, under glass, with 15 grains of nickel. The button weighs 290 grains, and is coated with black scale. It is more brittle than iron, and has a loose granular fracture and bright colour. Experiment by W. B. Richardson. *See* Percy's Metallurgy, Iron and Steel, p. 171, No. 2.

2684. Alloy of iron with 20 per cent. of nickel.

240 grains of iron were melted, under glass, with 60 grains of nickel. The button weighs 280 grains. Its surface is smooth and is free from scale. It is brittle and has a very irregular fibro-columnar fracture. It is bluish-white, and has a specific gravity of 7·917. Experiment by W. B. Richardson. *See* Percy's Metallurgy, Iron and Steel, p. 171, No. 3.

2685. Alloy of iron and nickel in equal parts.

200 grains of each metal were melted together, under glass. The resulting button weighs 380 grains. It is smooth, free from scale, and tarnishes yellow. It is very brittle. It has a uniform, even, finely granular fracture, with minute crystalline faces. Its specific gravity is 8·2. Experiment by W. B. Richardson. *See* Percy's Metallurgy, Iron and Steel, p. 172, No. 4.

2686. Experiment on the alloying of iron with cobalt.

200 grains of nearly pure hæmatite and 200 grains protoxide of cobalt were mixed and placed in a charcoal-lined plumbago crucible, the cavity being filled up with a mixture of china clay and lime, the pot luted over, and the whole exposed to a white heat for two hours. The result is a well fused button weighing 296 grains, attracted by the magnet. It flattened under the hammer and then broke. The fracture is granular, bluish-grey, with feeble lustre. It is accompanied by melted globules and a pale bluish-green glassy slag. It contains 46·71 per cent. of iron, and the remainder is cobalt. Experiment by R. Smith. *See* Percy's Metallurgy, Iron and Steel, p. 173.

2687. Second experiment on the alloying of iron with cobalt.

360 grains of nearly pure hæmatite and 40 grains of cobalt oxide were treated in the same way as in the last experiment. The result is a well fused button weighing 286 grains, attracted by the magnet. It has broken under the hammer. The fracture is granular, greyish-white in the centre, and on the outside is a very thin, fine-grained, dull, dark-grey layer. There are fewer globules, and a similar slag. It contains 87·21 per cent. of iron. Experiment by R. Smith. *See* Percy's Metallurgy, Iron and Steel, p. 173.

2688. Alloy of iron with 5 per cent. of aluminium.

950 grains of wrought iron were melted, and 50 grains of metallic aluminium were plunged in and stirred. The union of the metals seems here imperfect, and the whiter portion is so brittle as to be crumbling. Experiment by R. Smith.

2689. Experiment on the alloying of iron and magnesium.

140 grains of iron were melted with 20 grains of magnesium. The button weighs 160 grains. It has a rough, crystalline, granular fracture ; does not yield very readily to the hammer.

2690. Alloy of iron and magnesium.

2691. Alloy of iron and magnesium.

On analysis it yields only a trace of magnesium, carbon, and silica.

2692. Alloy of iron and tungsten, containing 9·5 per cent. of tungsten.

The complete analysis shows—

Carbon	1·123
Tungsten	9·477
Silicon	0·756
Manganese	0·520
Iron	88·124
	100·000

It contains no sulphur or phosphorus. In its present state it can be cut by a file; but after heating to red heat and quenching in water, it becomes much harder, and cannot be touched by a file. It has an exceedingly fine granular fracture. Analysed and communicated by W. Baker, 1874.

2693. Tungsten steel, said to contain 4 per cent. of tungsten.

Made by adding wolfram to molten steel. From Messrs. Seebohm and Co.'s Works, Sheffield. It has a fine silky fracture.

2694. Tungsten steel.

Manufactured at Siemens' Steel Works, Landore, 1870. It has a granular fracture, and possesses great power of retaining magnetism.

2695. Tungsten steel from Austria.

Exhibited at the Congress of Miners in Vienna, 1858. The fracture is remarkably fine, uniform, compact, and conchoidal. Not favourably reported on as to its working and other qualities by Mr. Saunderson, of Sheffield. Communicated by W. W. Smyth. *See* Percy's Metallurgy, Iron and Steel, p. 193.

2696. Experiments on the alloying of iron with chromium. Experiment I.

In all four experiments nearly pure red hæmatite was used, and prepared sesquioxide of chromium. The quantities were intimately mixed and placed in a charcoal-lined French crucible, the cavity filled up with charcoal powder, the whole luted over, and exposed to a white heat for two hours. In this first experiment 190 grains of hæmatite and 10 grains of chromium oxide were employed. The result is a well fused button with globules, and interlacing crystals on the surface. The fracture is white, bright, and crystalline. It is hard, and contains 4·24 per cent. of chromium. *See* Percy's Metallurgy, Iron and Steel, p. 187. Experiment by R. Smith.

2697. Alloying of iron and chromium. Experiment II.

150 grains of hæmatite and 50 grains of chromium oxide were taken. The result is a well fused button with globules, which is hard, brittle, with a tin-white, very bright, and finely granular fracture. It is crystalline in structure, and contains 72·93 per cent. of iron. *See* Percy's Metallurgy, Iron and Steel, p. 187.

2698. Alloying of iron and chromium. Experiment III.

150 grains of hæmatite and 150 grains of chromium oxide were taken, and half as much carbon was added more in the form of anthracite powder instead of charcoal. The result is a somewhat spongy button with metallic globules, not attracted by the magnet, hard, and with a finely granular, bright, greyish-white fracture. It contains 45·35 per cent. of iron. A slag is also produced in this case. *See* Percy's Metallurgy, Iron and Steel, p. 187.

2699. Alloying of iron and chromium. Experiment IV.

50 grains of hæmatite and 150 grains of chromium oxide were taken. The result is an imperfectly fused spongy mass less coherent than the last. It is not attracted by the magnet, is very hard, and can be crushed. The colour is yellowish-grey, and the lustre rather dull. In the centre are bright needle-shaped crystals. It contains 23·42 per cent. of iron. *See* Percy's Metallurgy, Iron and Steel, p. 187.

2700. Alloy of chromium and iron made by the reduction of chromium oxide in the electric furnace.

It contains 14 per cent. of chromium and the remainder is iron. It has rusted on the fractured surface. For the "electric furnace," *see* No. **2405.**

2701. Alloy of iron containing 5 per cent. of chromium.

It has a largely crystalline fracture and a greyish colour.

2702. Alloy of iron containing 10 per cent. of chromium.

It has a crystalline fracture and a whitish colour. It is hard enough to scratch glass.

2703. Alloy of iron containing 20 per cent. of chromium.

It has a crystalline fracture, with numerous narrow crystals, and is of a whitish colour. It scratches glass easily.

2704. Alloy of iron containing 30 per cent. of chromium.

This has a vesicular structure, being largely composed of brilliant, prismatic, interlocking crystals, with intervals between. The colour is white. It scratches glass with difficulty.

2705. Alloy of iron containing 40 per cent. of chromium.

It is finely vesicular, having an almost granular fracture, and a rather dull colour. It does not scratch glass.

2706. Chromium steel.

A sample of normal steel containing 0·90 per cent. of carbon, and a rod of chromium steel containing 5·95 per cent. of chromium, and ·308 of silicon. Communicated by C. V. Boys.

SPECIAL CASES OF THE REDUCTION AND CEMENTATION OF IRON.

2707. Clay ironstone cemented in charcoal.

No reduction has taken place. Prepared in the Metallurgical Laboratory of the Royal School of Mines.

2708. Hæmatite cemented in charcoal powder.

This is at the same time reduced to a mass of iron, which retains the kidney shape, the concentric layers and the radiating lines of the original ore. Prepared in the Metallurgical Laboratory of the Royal School of Mines.

2709. Cumberland hæmatite reduced direct.

This is a mass of iron, which retains the shape, and the concentric and radiating structure of the original ore, which has parted by open cracks. Communicated by R. Mushet, 1866.

2710. Red iron ore reduced by cementation in charcoal.

Communicated by S. Blackwell, 1867. This has the same appearance as the last, but is tinged with blue.

2711. Powdered clay iron ore reduced by means of charcoal.

A stick of charcoal has been placed in the centre of a retort, and surrounded by the powdered ore; this has been closed and heated. The result is a very porous, mostly metallic, iron mass. Prepared in the Laboratory of the Royal School of Mines.

2712. Accidental reduction of iron by coke.

A piece of coke has been imbedded by chance in the top cinder while the latter was being heated. The spot where it lay is now surrounded by a thin irregular sheet of reduced iron.

2713. A series of specimens illustrating the carburisation of ore by means of the furnace gases.

No. 1. The calcined ironstone which was exposed to the furnace fumes. It is derived from the Cleveland iron ore. No 2 is the same after exposure to the escaping gases of a furnace 48 feet high for 24 hours. No. 4 is another sample of calcined Cleveland ore, containing 42·2 per cent. of iron. No. 3 is this sample after it has been subjected to the gases of a furnace 80 feet in height for 24 hours.

EXPERIMENTS ON METEORIC IRON.

Conducted by R. Smith, on portions of the largest meteorite in the British Museum and on the rust derived from it.

2714. Pieces of the meteoric iron as received.

They are all small fragments, and are mostly changed to ferric oxide. They exhibit a pseudo-columnar structure.

2715. Meteoric iron. Rusted portion reduced by carbonic oxide gas.

The material has been heated in a crucible placed within another and filled up with anthracite powder. The result is that irregular metallic masses are produced, black on the surface, purplish-white within, and showing an irregular, prismatic structure.

2716. Meteoric iron. Rusted portion reduced by hydrogen gas and cooled in the same. Experiment I.

It forms irregular, prismatic, metallic masses of purplish hue.

2717. Meteoric iron. Rusted portion reduced by hydrogen. Experiment II.

It was heated in hydrogen for two hours and left to cool for two hours more in hydrogen. The result is very similar to the last, but the lustre is a little more brilliant.

2718. Meteoric iron. Rusted portion reduced in hydrogen and afterwards remelted.

A portion was selected showing Wiedmanstattian figures, and this was fused under glass and allowed to cool in the furnace. The arborescent, crystalline structure is now well seen on the surface and top of the melted button, which has a coarse crystalline fracture.

2719. Meteoric iron. Metallic portion melted under plate glass and allowed to cool in the furnace.

It weighs 1,292 grains. The fracture is granular, and the crystalline structure of the surface so minute as to be almost invisible.

2720. Meteoric iron. Metallic portion melted under glass, and allowed to cool in the furnace. Second experiment.

The button weighs 1,340 grains, and the whole of the surface is covered by arborescent crystallisation.

2721. Meteoric iron. Metallic portion melted under glass, and allowed to cool in the furnace. Third experiment.

The fracture is finely granular, and no crystallisation is visible on the surface.

2722. Meteoric iron, run into moulds and hammered. Made from the rusted portion after reduction by cementation in charcoal.

IRON ORES.

BRITISH.

Magnetic Iron Ores.

2723. Magnetic iron ore from Rosedale, Yorkshire.

This is a black mass, belonging to the base of the Inferior Oolite. It is oolitic in structure, and appears to have been primarily calcareous. Then the lime was replaced by iron, and, finally, the carbonic acid has, for the most part, escaped. It is mixed with some clay. Analyzed by E. F. Techmacher.

Oxide of iron - - -	74·48
Alumina - - - -	3·20
Silica - - - -	6·70
Lime - - - - -	0·35
Magnesia - - - -	0·25
Water and loss - - -	15·02
	100·00

This gives a per-centage of 55 of metallic iron.

2724. Magnetic iron ore from Rosedale, Yorkshire.

Another portion of the same mass, assaying only 41·5 per cent. of iron.

2725. Magnetic iron ore from Rosedale, Yorkshire.

From the south drift. A blue-black variety, containing 39·38 per cent. of metallic iron. Communicated by A. C. Sheriff. *See* Percy's Metallurgy, Iron and Steel, p. 235.

2726. Magnetic iron ore from Rosedale, Yorkshire.

From the old drift. A bluish dark grey variety, containing 38·44 per cent. of metallic iron. Communicated by A. C. Sheriff. *See* Percy's Metallurgy, Iron and Steel, p. 235.

2727. Magnetic iron ore from Limerick.

A concretionary mass, partly weathered to brown oxide.

2728. Magnetic iron ore from near Torquay, Devonshire.

A crystalline vein-substance, probably in Devonian rocks, accompanied by fibrous hornblende. Yields 58·93 per cent. of metallic iron.

2729. Magnetic iron ore from Dolgelly, N. Wales.

A fine grained, crystalline vein substance, probably in Cambrian rocks, in which brilliant octahedra of magnetite may be seen. Analysed by W. J. Ward. It contains 41·58 per cent. of metallic iron, 0·29 per cent. of phosphorus, and 0·17 per cent. of sulphur. There is an insoluble residue of 25·76 per cent. and a loss on ignition of 3·92 per cent. Communicated by Brassey and Co., 1867.

Hæmatites.

2730. Micaceous iron ore from Cornwall.

Obtained from a fissure. It contains 77·20 per cent. of ferric oxide, equivalent to 54·03 per cent. of metallic iron. Only a small portion of the powder is taken up by the magnet. Analysed by R. Smith. Communicated by Mr. Murray.

2731. Micaceous iron ore from Wadebridge, Cornwall.

A concretionary mass with radiating crystals of black oxide passing to red kidney ore. Used at Blaina Ironworks in 1859.

2732. Specular iron ore from Birkershanon, Eskdale.

Communicated by F. H. Noyes.

2733. Kidney iron ore from the New Vein, Birkershanon, Eskdale.

Communicated by F. H. Noyes.

2734. Micaceous iron ore from Bovey Tracey, Devonshire.

A brittle mass, going down into powder of purplish tint. It contains 57·57 per cent. of metallic iron.

2735. Micaceous iron ore from Devonshire.

Communicated by D. Pridham, 1867. Similar to the last. Occurs as a vein in the Devonian rocks.

2736. Earthy red hæmatite from Somersetshire.

Contains 46·03 per cent. of metallic iron. It forms part of the Dolomitic Conglomerate of the Trias. Communicated by R. Bristowe.

2737. Iron ore from Luccombe, Somerset.

This is a sandstone of the Trias, deeply impregnated with ferric oxide between the grains of sand, and forms part of the Dolomitic Conglomerate. Communicated by R. Bristowe.

2738. Hæmatite from Luccombe, Somerset.

This is more or less in the micaceous form. It consists of a breccia, in the Triassic rocks, which had the interstices infiltrated by the ferric oxide. It contains therefore many fragments of stone, and forms part of the series called the Dolomitic Conglomerate. Communicated by R. Bristowe.

2739. Ironstone from the Trias of Luccombe, Somerset.

Fragments of stone imbedded in an abundant matrix of red hæmatite, and forming part of the Dolomitic Conglomerate. Communicated by R. Bristowe.

2740. Kidney ore from Cleator, Whitehaven, Cumberland.

Communicated by M. Blackwell.

2741. Red and black kidney ore from Ulverstone, Lancashire.

2742. Puddling ore from Ulverstone.

This is most suitable for putting on the bottoms of puddling furnaces. Communicated by Mr. Roper, Newland furnace.

2743. Blast ore from Ulverstone.

This is not so suitable for puddling, but is used in the blast furnaces. Communicated by Mr. Roper.

2744. Gravelly iron ore from Ulverstone.

All these ores from Ulverstone and Cleator occur in fissures and nests in the Carboniferous Limestone.

2745. Five samples of varieties of hæmatite iron ore in powder.

As used by the Whitehaven Hæmatite Iron Co.

2746. Hæmatite iron ore as used at Dowlais Furnaces, 1870.

2747. Another more earthy variety of hæmatite used at Dowlais Furnaces, 1870.

2748. Hæmatite from the Mumbles, Swansea.

Contained in a slickensided vein in the Carboniferous Limestone.

2749. Dark hæmatite from the Forest of Dean.

This is a very solid mass of fine grain, weathering red, of concentric structure and conchoidal fracture.

2750. Iron ore from Ashton-under-Lyne.

Doubtless from the Trias. It is a red, earthy, fissure-material with cavities, and contains sulphate of barium. Communicated by E. Riley, Dowlais.

2751. Hæmatite from Winsford, Somerset.

A compact, earthy, red mass, with geodes of quartz crystals. In the mountain limestone of the Mendip Hills.

2752. Hæmatite from Ilfracombe, North Devon.

A radiating concretionary mass containing 82·64 per cent. of ferric oxide, equivalent to 57·84 per cent. of metallic iron.

2753. Iron ore from the Carboniferous Limestone of Pembrokeshire.

This consists of models in hæmatite of numerous organic remains which were of course originally composed of carbonate of lime, which has been replaced by the iron oxide. Portions of Encrinites and of Bryozoa have been detected in it by J. W. Salter.

2754. Iron ore from the "Crane" Iron Works.

This consists of a cavernous mass, with long, parallel, hollow spaces, round which the ferric oxide is accumulated, covered with red powder.

2755. Iron ore quarried near Berry Head, Tavistock, on the shore and inland.

Massive hæmatite, partially converted into limonite.

Brown Hæmatites.

2756. Iron ore from Tynardreath, Par Station, Cornwall.

Banded vein-stuff, containing 63·31 per cent. of metallic iron. Communicated by Wm. Polkinghorne.

2757. Iron ore from Tynardreath, Par, Cornwall.

Dark crystalline material with fragments. Contains 43·88 per cent. of metallic iron.

2758. Brown iron ore from Ilsington, Devon.

Irregular, tubular masses of dark limonite. Used at the Atlas Iron Works, Bovey. Communicated by W. W. Smyth.

2759. Brown iron ore from the Brendon Hills, Somerset.

A dark, irregular, porous, banded mass, used at the Ebbw Vale Iron Works, 1859. Associated with spathic ores in the Devonian slates.

2760. A mixed ore from the mines at Perran, Cornwall. Analysed by W. J. Ward.

Ferrous oxide	27·19
Ferric oxide	18·34
Manganous oxide	5·62
Alumina	2·81
Lime	4·68
Magnesia	0·88
Phosphoric acid	2·84
Sulphur	0·83
Carbonic acid	21·23
Silica	11·83
Water	3·15
	99·40

This is equivalent to 34·07 per cent. of metallic iron. An irregular, breccia-like spathose rock.

2761. Brown iron ore from Perran Iron Mines, Cornwall.

Porous concretionary masses. Analysed by W. J. Ward, 1870.

Ferric oxide	74·94
Manganous oxide	3·07
Alumina	1·70
Lime	0·48
Magnesia	0·07
Phosphoric acid	0·81
Sulphuric acid	0·09
Silica	5·79
Water	12·79
	99·74

This is equivalent to 52·45 per cent. of metallic iron.

2762. Brown hæmatite from Froghall, near Cheadle, Staffordshire.

It is a calciferous brown hæmatite, occurring in the latest portion of the Coal Measures. It is compact, homogeneous, and brownish-red in colour and has a vein of calcareous spar. Analysed, when dried, by A. Dick.

Iron oxide	52·83
Manganous oxide	0·81
Lime	14·61
Magnesia	5·70
Carbonic acid	18·14
Phosphoric acid	0·32
Sulphuric acid	0·28
Combined water	4·75
Organic matter	1·30
Ignited insoluble residue	0·04
	98·78

See Percy's Metallurgy, Iron and Steel, pp. 207, 224.

2763. Brush iron ore, Forest of Dean

A concretionary solid brown ore. For analyses of these so called ores, *see* Percy's Metallurgy, Iron and Steel, p. 207. One variety contains 90 per cent. of ferric oxide. It is derived from the Coal Measures.

2764. Forest ore, or Smith ore, Forest of Dean.

An earthy brownish-red gravelly ore, derived from the Coal Measures. An analysis of this ore, but not of this sample, by A. Dick, gave 89·76 per cent. of ferric oxide, with 7 per cent. of water, and fractions of the usual bases and of phosphoric acid. *See* Percy's Metallurgy, Iron and Steel, p. 207.

2765. Forest of Dean ore

Used at the Dowlais Iron Works, 1870. A tufaceous mass with small parallel hollows.

2766. Botryoidal and stalactitic brown hæmatite from the Forest of Dean coal measures.

Massive within and with radiating crystals on the surface.

2767. Iron ore from the Forest of Dean, ground and prepared as a red colouring matter.

2768. Iron ore from the Forest of Dean, ground and prepared as a brown colouring matter.

2769. Bog iron ore, from Ireland.

A solid irregular mass, in parts nearly black.

2770. Aluminous iron ore from Antrim, north of Ireland.

A dark, reddish-brown granular mass, with black pebbles. It has a specific gravity 2·9, and contains 40·49 per cent. of metallic iron. Communicated by Mr. Bauerman. Compare the analyses, p. 207 of Percy's Metallurgy, Iron and Steel.

2771. Aluminous iron ore from Belfast.

Used at the Dowlais Iron Works, 1870. It consists of a breccia of darker red fragments in a light red matrix and is entirely soft and earthy.

2772. Iron ore from Arklow, Ireland.

Used at the Dowlais Iron Works, 1870. Consists of a porous, dark, concretionary mass.

2773. Iron ore from the north of Ireland.

A red earthy mass, which yielded on analysis, ferric oxide, 59·08; alumina, 27·30; silica, 8·80. The loss on calcination was 6·86 per cent. and the ignited insoluble residue, 21·37 per cent. There is 41·36 per cent. of metallic iron. These ores occur in lenticular beds, associated with the dolerites of Antrim and are of Tertiary age.

2774. Iron ore from the north of Ireland.

A brownish red earthy soft mass. Yielding on analysis 35·20 per cent. of ferric oxide, 38·22 of alumina, 6·06 of silica. The loss on calcination is 24·26, and the ignited insoluble residue is 24·90. This yields 24·64 per cent. of metallic iron when raw, 31·29 when calcined.

2775. Iron ore from the north of Ireland.

A dark irregular earthy mass of various red and brown colours, yielding on analysis 77·84 per cent. of ferric oxide, 2·16 of ferrous oxide, 7·16 of alumina, 11·92 of silica. The loss on ignition was 3·24 per cent. and the ignited insoluble residue was 20·31. This yields 56·17 per cent. of metallic iron. None of these three ores contain any sensible proportion of phosphorus or sulphur.

2776. Northampton iron ore.

Used at the Dowlais Iron Works, 1870. An earthy hydrated sesquioxide of iron, oolitic in structure and ochre-brown in colour. More or less concretionary. It belongs to the lower part of the Inferior Oolite. These ores contain about 51 per cent. of ferric oxide with 14 per cent. of insoluble residue. It was one of these specimens of Northampton iron ore to which Dr. Percy directed the attention of Mr. Blackwell, of Dudley, and thus led to its introduction into extensive use. *See* Phillip's Ores and Ore Deposits, p. 172.

2777. Northampton iron ore.

Used at Dowlais Iron Works, 1870. This is a vacuous ore, from which all the calcareous particles have been dissolved, leaving minute hollow spaces separated by the insoluble ferric oxide.

2778. Northampton iron ore showing the origin of the ferric oxide by the weathering of the carbonate.

Both parts are of oolitic structure. The interior is bluish green, the outside shows a concretionary deposit of ferric oxide. In Dr. Percy's Metallurgy, Iron and Steel, p. 209, are given analyses by A. Dick of the inner and outer portions of this or a similar specimen. They are—

	Outer part.	Inner part.
Ferric oxide	38·04	—
Ferrous oxide	10·54	33·29
Manganese oxide	0·69	1·11
Alumina	12·35	4·62
Lime	trace	0·52
Magnesia	4·13	7·96
Silica	1·96	1·99
Carbonic acid	0·16	24·79
Phosphoric acid	0·26	0·22
Iron bisulphide	0·13	0·13
Water (combined)	6·92	0·54
Organic matter	0·19	0·08
Insoluble residue	24·61	24·07
	99·98	99·32

2779. Series of specimens (5) of "iron ore" from Banbury.

These belong to the Marlstone of the Middle Lias. They cannot be regarded as iron ore properly so called, as the sample analysed by A. Dick (*see* Percy's Metallurgy, Iron and Steel, p. 209) gave only 3·19 for ferric oxide and 12·34 of ferrous oxide.

2780. Iron ore from a "seven foot bed" at Thirsk, Yorkshire.

This is an oolitic carbonate mostly converted into hydrated sesquioxide of iron. It belongs to the lower part of the Inferior Oolite.

2781. Vanadium compound obtained from Westbury iron ore.

It is a green amorphous powder. The Westbury iron ore is an oolitic deposit belonging to the Upper Oolites. Communicated by E. Riley, 1881.

2782. Oolitic iron ore from the Tealby Series, Lincolnshire.

This belongs to the Middle Neocomian series. It is composed of black grains of hydrated ferric oxide imbedded in an earthy matrix of similar material. Analysed by W. J. Ward in 1873. Yields 27·83 per cent. of metallic iron.

2783. Iron ore from East Cliff, Hastings.

A nodular concretion from the Wealden clays, similar to those once smelted in Kent and Sussex.

2784. Earthy brown hæmatites from Alston Moor.

Various superficial masses produced by weathering vein-stuffs, and forming a gossan. Analysed by Dr. Percy in 1848.

2785. Impregnation of wood (?) by hydrated ferric oxide, at Alston Moor, with small crystals of baryta.

2786. Brown hæmatite from Llantrissant, Glamorganshire.

From a remarkable deposit forming in the base of the Magnesian conglomerate and resting on the Carboniferous Limestone. Analysed by E. Riley, gives 59·05 per cent. of ferric oxide, 34·40 per cent. of silica, 6·14 of combined water and fractions of manganous oxide, lime, magnesia, phosphoric acid, and pyrites, and yields 41·34 per cent. of metallic iron. This specimen, however, contains a fair amount of calcite.

2787. Clay ironstone from the Wealden on the shore near Hastings.

Red on the surface by weathering to ferric oxide, reddish-brown within where unweathered, and with root-like markings coloured green as by iron carbonate.

2788. Ironstone from the Upper Eocene clays of Christchurch, Hants.

A fine-grained sandy mass. Smelted at Ebbw Vale Iron Works in 1865.

Spathic Iron Ores.

2789. Spathic iron ore from Cornwall.

A compact, finely crystalline mass. Communicated by Mr. Conybeare.

2790. Spathic iron ore from the Brendon Hills, Somersetshire.

A coarsely crystalline mass of characteristic brownish tint. It occurs as a vein in the Devonian series, and is, or has been, much worked by the Ebbw Vale Iron Company. Dr. Percy (Metallurgy, Iron and Steel, p. 210) gives an analysis of this ore showing 43·84 of ferrous oxide, 12·64 of manganous oxide, 3·63 per cent. of magnesia, and 38·86 per cent. of carbonic acid. This corresponds to 34·67 per cent. of metallic iron.

2791. Spathic iron ores from the Brendon Hills, Somerset, assayed from iron, showing variety of yield.

Analysed by W. J. Ward, 1875. No. 1, taken from the ore as delivered at the Ebbw Vale Iron Works, yields 33·87 per cent. of metallic iron. No. 2, from the same lode, two miles west of Lockyard, yields 27·32 per cent. No. 3, from the same lode, taken as delivered at the Ebbw Vale Iron Works, yields 33·96 per cent. No. 4, in a partially decomposed state by which the carbonate has partly become oxide, yields 35·27 per cent. These ores are specially employed for the manufacture of spiegeleisen.

2792. Spathic iron ore from the Brendon Hills, Somerset, containing patches of copper pyrites.

2793. White spathic iron ore from Perran, Cornwall.

A compact, finely crystalline mass from a band in the Devonian slates. Analysed by W. J. Ward, 1870.

Ferrous oxide - - - -	40·67
Ferric oxide - - - -	5·81
Manganous oxide - - -	9·12
Alumina - - - -	0·93
Lime - - - -	2·92
Magnesia - - - -	1·49
Phosphoric acid - - -	0·94
Sulphur - - - -	0·31
Silica - - - -	2·96
Carbonic acid - - - -	32·85
Water - - - -	1·40
	99·40

This is equivalent to a yield of 35·67 per cent. of metallic iron.

2794. Spathic iron ore from Devonshire.

A finely crystalline mass, containing 73·41 per cent. of ferrous carbonate and 18·22 per cent. of manganous carbonate, which is equivalent to 35·44 per cent. of metallic iron and 11·25 per cent. of manganous oxide. Communicated by Sir Lawrence Palk.

2795. Spathic iron ore from Co. Fermanagh, Ireland.

A brecciated mass, with a concretionary coating of hydrous ferric oxide. The interior is mottled white and dark green. This inner portion, assayed by R. Smith, gives 74·41 of ferrous carbonate, which is equivalent to 35·92 per cent. of metallic iron.

2796. Spathic iron ore from Weardale, Durham.

A coarsely crystalline mass, forming a vein in the Carboniferous Limestone. A specimen (? this one) from this lode, analysed by C. Tookey, gave per cent. 49·77 of ferrous oxide, 37·20 of carbonic acid, 3·96 of lime, and 2·83 of magnesia. This is equivalent to 38·95 per cent. of metallic iron.

2797. Spathic iron ore from Great Ormes Head, North Wales.

On the west side, near the level of the copper mine, from an old dressing floor on the shore, probably forming the gangue of the copper vein, as in No. **2792**.

2798. Spathic iron ore from Llandudno.

It occurs in a vertical cleft or fissure, and is accompanied by soft ochre-like stuff, derived from its decomposition into a brown hæmatite.

2799. Crystalline chalybite formed on the surface and fissures of a septarium of red hæmatite.

From Wadebridge, Cornwall. Used at the Blaina Iron Works, 1889. The crystals are well-formed rhombs.

2800. "Balls" iron ore.

Used at Russell Hall's furnaces, Dudley. It consists of the usual argillaceous iron ore of the coal measures, coated over with sheets and little tufted crystals of chalybite. In one specimen it is associated with pyrites similarly disposed.

2801. Spathic ore on the surface of the fissure of a septarium of Welsh clay-ironstone.

Used at Ebbw Vale Iron Works, 1865.

2802. Mass of quartz in the midst of spathic iron ore which has not been picked out as it ought to be from the material to be smelted, showing the accidental source of some irregularities in working the ore.

Argillaceous Ores.

2803. Cleveland iron ore.

This is from the main seam, belonging to the Middle Lias. It is a bluish-green oolitic rock in which many of the original grains have been converted into earthy carbonate of iron, which is much mixed with impurities. As analysed by A. Dick it yields 39·92 per cent. of ferrous oxide, 22·85 of carbonic acid, with considerable amounts of alumina, lime, and silica, the total iron being 33·62 per cent. *See* Percy's Metallurgy, Iron and Steel, p. 221.

2804. Earthy iron ore from Duston, Northamptonshire

This belongs to the lower part of the Inferior Oolite, and by weathering produces the surface ores, Nos. **2776–8**. It is an oolitic rock, originally calcareous, and now for the most part converted into an impure carbonate of iron. Assayed by R. Smith, and yields 38·13 per cent. of metallic iron and 1·85 per cent. of phosphoric acid.

2805. Black-band ironstone from Llynvi Coal and Iron Company.

This is a black argillaceous band in the South Wales Coal Measures. It contains 34 per cent. of metallic iron, in the form of admixed carbonate.

2806. Another sample of black-band ironstone from the Llynvi Coal and Iron Company.

This contains 35·22 per cent. of metallic iron. Both analysed by W. J. Ward, 1868.

2807. Bedded ironstone, called "Caus-y-glo," Ystalyfera.

This is one of the best quality. A sample which corresponds to this in description analysed at the Woolwich Arsenal gave 33·45 per cent. of metallic iron. It is from the Coal Measures of South Wales.

2808. Septarian ironstone, called "Coed folde," Ystalyfera.

From the South Wales Coal Measures. This is also called "white mines" or "balls and pins," this specimen being from one of the balls. The two united were analysed by A. Dick and found to contain 29·34 of ferrous oxide, 25·56 of carbonic acid, and 35·73 of insoluble residue, or 23·22 per cent. of metallic iron. *See* Percy's Metallurgy, Iron and Steel, p. 220; and Iron Ores of Great Britain, Part III., p. 212.

2809. Pennystone ironstone, Ystalyfera, South Wales.

This is a small flat nodule of argillaceous ironstone, occurring separately in the Coal Measure clays.

2810. Argillaceous ironstone from Bedworth, near Coventry, Warwickshire.

A reddish rock in the Coal Measures. Analysed in 1846 by Dr. Percy. It yields—

Ferrous oxide	48·70
Manganous oxide	0·90
Alumina	0·50
Lime	3·25
Magnesia	3·05
Silica	4·85
Carbonic acid	36·89
Phosphoric acid	0·71
Water	1·15
	100·00

See Percy's Metallurgy, Iron and Steel, p. 217.

2811. Argillaceous ironstone, called Welsh Mine, Dowlais, Glamorganshire.

There are numerous beds included under this head, some named the Little Blue vein, others the Lumpy vein, of which analyses by

E. Riley, at Dowlais, are given by Dr. Percy, Metallurgy, Iron and Steel, p. 218. This appears to belong to the Lumpy vein, which contains 34·72 per cent. of metallic iron.

2812. "Welsh Mine" iron ore, calcined before smelting.

From the Dowlais Iron Works, 1870.

2813. Clay ironstone from the Coal Measures, Moreton Colliery, near Tenby.

It is part of a septarian nodule.

2814. Hatchettine from Merthyr Tydvil, Glamorganshire.

A soft, easily fusible mineral, allied to the paraffins, occurring in the crevices of the clay ironstone in this, the original, locality. *See* Conybeare, Ann. Phil. Vol. 1, p. 136, 1822.

2815. Llwynenion ironstone, British Iron Company's Works, Ayre Fair, Ruabon, Denbighshire.

A fine-grained, reddish, argillaceous mass from a nodule.

2816. Ironstone of the "stone" coal, Ayre Fair, Ruabon, Denbighshire.

This is black, and contains remains of *Anthracosia.* It is considered the best in the district. Communicated by W. W. Smyth.

2817. Llwynenion ironstone, lower seams, Ayre Fair, Ruabon, Denbighshire.

This is darker than the last.

2818. "Blue Flats" ironstone from Somerford Colliery, South Staffordshire.

An ironstone of very limited geographical range, only between Wolverhampton and Walsall. It consists of flat beds; one of these pieces shows the remains of *Calamites*, the other of *Productus*, being part of a nodule weathering a purplish blue. This measure has been analysed by C. Tookey, and yields ferrous oxide 42·34 per cent., carbonic acid 30·91, and insoluble residue 15·50, being equivalent to 34·41 per cent. of metallic iron. *See* Percy's Metallurgy, Iron and Steel, p. 215.

2819. "Cranstone" ironstone, Madeley, Shropshire.

This is the lowest in the district, and occurs in the form of nodules. A specimen of this ore has been analysed by J. Spiller, and gives ferrous oxide 51·45, carbonic acid 33·31, and insoluble residue 9·60, equivalent to 40·27 per cent. of metallic iron. *See* Percy's Metallurgy, Iron and Steel, p. 218.

2820. Pennystone ironstone, Madeley, Shropshire.

A small concretion of reddish clay ironstone, with a septarian centre. A specimen of this ore has been analysed by J. Spiller, and yields ferrous oxide 44·19, carbonic acid 32·02, insoluble matter 13·50, equivalent to 34·75 per cent. of metallic iron. *See* Percy's Metallurgy, Iron and Steel, p. 218.

2821. Nodular form of the Pennystone ironstone, Madeley, Shropshire.

2822. Clay ironstone, employed at the Newland furnaces, Ulverstone, Lancashire, for mixing with the hæmatite ores to form a slag.

2823. Earthy iron ore from Co. Fermanagh, Ireland.

A rough solid mass. Analysed by R. Smith. It contains 75·92 per cent. of ferrous carbonate, equivalent to 36·65 per cent. of metallic iron, and 11·40 per cent. of manganous carbonate, equivalent to 7·04 per cent. of manganous oxide.

2824. Calcined iron ores from Co. Fermanagh, Ireland.

Analysed by R. Smith, contains 29·83 per cent. of metallic iron.

2825. Brown iron ore from co. Fermanagh, Ireland.

An earthy nodule with dense coating. Analysed by R. Smith, contains 38·97 per cent. of metallic iron. It loses 18·33 per cent. on calcination.

2826. Clay iron ore from South Staffordshire, containing blende and iron pyrites.

The blende is in considerable crystalline masses in the centre of the ironstone nodule and is sprinkled with mamillæ of iron pyrites.

2827. Nodule of clay ironstone, containing massive iron pyrites in large crystals.

2828. Iron ore from Wales.

It is black, shaley, and oolitic. Probably it is the pisolitic iron ore characteristic of the lower part of the Silurian series.

2829. Massive oolitic iron ore from the Silurian series of Carnarvonshire.

2830. Carbonaceous clay ironstone called "Duffryn Brass." Dowlais, South Wales.

A brownish-grey stone called by this name, analysed by E. Riley, was found to contain 58·48 per cent. of carbonate of iron and 8·95 per cent. of coal. *See* Percy's Metallurgy, Iron and Steel, p. 203. This is composed of minute fragments of coal set in a black earthy paste.

2831. Clay ironstone septarian nodule, coated along the cracks with pearl spar in rhombs and sprinkled with copper pyrites in double pyramids.

From Somerford Colliery, near Wolverhampton.

2832. Clay ironstone, containing galena in the form of a slight incrustation.

From the "Wall and Bench" Coal, Ayre Fair Works, Ruabon, Denbighshire.

2833. Piece of weathered clay-ironstone, showing the conversion of blue carbonate into the brown hæmatite on the surface.

By a ruined blast furnace. Melincourt Fall, Resolven, near Neath.

2834. Iron ore from the upper part of the Lower Greensand, near Bonchurch, Isle of Wight.

An earthy nodule, containing 38·15 per cent. of metallic iron.

2835. Clay iron ore dredged up off the coast of the Isle of Wight and sent to Cardiff where it was sold for 10s. a ton, and used in considerable quantity at the Ebbw Vale Iron Works.

It is a nodule from the ironstone beds of the Lower Greensand series.

2836. A black oolitic iron ore from Ireland.

Examined by Dr. Percy for Mr. Blackwell. Locality unknown.

2837. Carbonaceous ironstone called "Brass" from the Park Pits, South Wales.

Contains 27·88 per cent. of metallic iron and is coarse grained and black.

2838. "Brass" iron ore, occurring in the coal at Blaenavon, South Wales.

2839. "Coal Brass" iron ore from the Ocean Steam Company's Pits, Ystradd, Pont-y-pridd, South Wales.

Analysed by R. Smith.

Ferrous carbonate	65·05
Magnesium carbonate	21·32
Calcium carbonate	4·57
Manganous carbonate	1·02
Coal	6·26
Ferric oxide	0·53
Silica	0·45
Alumina	0·01
Phosphoric acid	0·03
Ferrous sulphide	0·06
Water	0·06
	99·36

Equivalent to 31·78 per cent. of metallic iron.

2840. Gossan iron ore containing tin.

From Holme Chase, Ashburton, Devonshire. Communicated by Geo. Malcolm. A brown irregular mass, accompanied by a button of tin which has been melted out of a portion of it.

FOREIGN IRON ORES.

Ores from France.

2841. Ironstone from Niedepas, Ariège, France.

An alternation of bands of siliceous and ferruginous matter which have been squeezed together. Apparently not rich in iron.

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2842. Mammillated brown hæmatite from Ariège, France.

Massive within and with radiating nearly black crystals on the surface.

2843. Brown hæmatite from Ariège, France.

This shows radiate crystallisation in various parts of its mass, mixed with earthy parts and is remarkably smooth on one surface.

2844. Iron ores from Cherbourg.

These are micaceous hæmatite of greater or less purity. There are four samples, the most micaceous from 11 metres below the surface. Second. 15 metres below the surface. Third, more massive from La Roche Dion, and fourth, earthy looking and compact from La Roche Dion. Analysed by W. J. Ward, 1866.

Iron ores from Holland.

2845. Bog iron ore from old lake deposits in Holland.

A brown concretionary limonite of quaternary age. Communicated by J. E. de Fry.

2846. Bog iron ore from Holland.

A more completely solidified mass of the same kind. Communicated by Mr. Bleekrode.

Iron ores from Germany.

2847. Spathic iron ore from Siegen, Rhine Provinces.

A massive ferrous carbonate occurring in a vertical wedge-shaped vein in the Coblentz slates of the Lower Devonian period. *See* Phillips' Ores and Ore Deposits, p. 272.

2848. The same spathic iron ore from Siegen after calcination.

2849. Variety of spathic iron ore from Siegen, containing some copper pyrites.

See Phillips' loc. at p. 273.

2850. Iron ore from Westphalia.

It consists of a deposit of quartz sand, consolidated by ferric oxide on the surface but lying loose in the interior.

2851. Iron ore from Westphalia.

A ferruginous grit. Communicated by Mr. Ormsby.

2852. Clay iron ore from Westphalia.

Communicated by Mr. Ormsby. Appears to be part of a nodule.

2853. Bog iron ore from Olfen, Westphalia.

Used largely in Prussia. A dark concretionary mass of dark brown limonite in small globules, similar to that formed in the Old Lakes of Holland.

2854. Red hæmatite from the North of Germany.

Possibly from Elburgerode in the Harz where red hæmatite is worked, contains 67·25 per cent. of metallic iron. Analysed by R. Smith.

2855. Spathic and brown iron ore from Germany.

Possibly from the Siegen district. Consists of a vein of fine ferrous carbonate bounded by slate infiltrated by ferric oxide.

2856. Oolitic iron ore from 12 miles south of Hanover.

This is probably from the neighbourhood of Salsgitter, where such oolitic iron ore, which is of the age of the Tealby iron ore, *i.e.* Neocomian, which it much resembles, is worked. Communicated by Mr. Hedley.

2857. Another example of the same oolitic iron ore.

This is very much redder, especially in the matrix, which is not brown but red. Communicated by Mr. Hedley.

Iron ores from Spain.

2858. Specular iron ore from Marbella, Spain.

A black foliated mass of micaceous iron ore with a reddish dust.

2859. Micaceous iron ore from Marbella, Spain.

A very fine grained black foliated mass. Smelted at Dowlais Iron Works, 1870.

2860. Iron ore from Carthagena, Spain.

A concentrically banded black concretionary mass, passing to a red colour on the surface. Smelted at Dowlais Iron Works, 1870.

2861. Brown iron ore from Spain.

A black and brown concretionary mass of limonite, containing 53·33 per cent. of metallic iron. Communicated by J. Joule, 1873.

2862. Iron ore from Santander, north-west of Spain.

A red earthy hæmatite, partly changed to limonite and bound by irregular bands of black oxide. Smelted at Dowlais, 1870.

2863. Altered spathic iron ore from Garucha, Spain.

A solid mass with hollow spaces lined with crystals. These have the rhombohedral form of ferrous carbonate, but are mostly decomposed to a brown oxide, *i.e.*, they are pseudomorphs of limonite after chalybite.

2864. Spathic iron ore from Bilbao, Spain.

This is a crystalline mass, with faces arranged nearly parallel to those of a rhombohedron, but it is black externally and red dust internally, so that it is a decomposed chalybite, mostly now hæmatite. It contains 15·58 per cent. of metallic iron.

2865. Micaceous hæmatite from Bilbao, Spain.

Smelted at Dowlais. A solid mass composed of irregular hæmatite crystals with red powder on the surface.

2866. Specimen illustrating the conversion of iron pyrites into brown iron ore.

From Santander, Spain. Communicated by Mr. Bauerman, 1873.

No. 1 is a mass of pyrites, partially converted into brown hæmatite, but still showing its original nature. No. 2 shows the cubical crystals of pyrites in its drusy cavities, but they are entirely converted into brown hæmatite. No. 3 is a massive piece, with a few druses entirely altered into hæmatite. No. 4 is a stalactitic vacuous mass obviously formed by the evaporation of water containing a salt of iron solution.

2867. Limonite from Ribetto, San Pedro.

A brown, banded, earthy deposit, of obviously modern formation.

Iron ores from Portugal.

2868. Massive brown hæmatite from Mongas, near Lisbon.

Analysed by W. J. Ward, 1867. Communicated by Mr. Oakes.

Contains 82·48 per cent. of ferric oxide. The remainder is 5·91 clay and sand, 8·20 loss on calcination. There is a trace of phosphorus and 0·15 per cent. of sulphur. This is equivalent to 57·74 per cent. of metallic iron.

2869. Second specimen of hæmatite from Mongas, near Lisbon.

The two were averaged by the above analysis.

2870. Iron ore from Portugal.

Smelted at the Dowlais Iron Works, 1870. A semi-micaceous, partially vacuous mass of black colour, weathering brown.

Iron ores from Sweden and Norway.

2871. Micaceous iron ore from the Jarna Mines, Sweden.

A compact crystalline black mass of ferric oxide.

2872. Micaceous iron ore from the Torola Mines, Sweden.

A similar compact crystalline mass.

2873. Micaceous iron ore from Petters Mine, Thorsaker, Sweden.

A fine grained black crystalline rock with feeble signs of foliation.

2874. Micaceous iron ore from the Ys Mine, Thorsaker, Sweden.

A very fine grained, somewhat foliated mass of black crystals.

2875. Iron ore from the Stenebo Mines, Sweden.

An excessively fine grained, foliated and banded rock. This is the only ore of the above five which cannot be smelted by the simple addition of a suitable quantity of lime, but requires 50 per cent. of slag. All of these were communicated by C. Eckman in 1848. They occur as portion of the crystalline schists of the Archæan epoch.

2876. Micaceous iron ore from Sweden, locality unknown.

It contains 60·37 per cent. of metallic iron, has an insoluble residue of 14·07, and contains traces of phosphorus and sulphur.

2877. Coarse micaceous iron ore from Långban, Wermland, Sweden.

2878. Fine micaceous iron ore from Långban, Wermland, Sweden.

A very massive compact rock of black colour.

2879. Rock from the Petersberg Mines, Wermland, Sweden.

This is a basic crystalline rock, and does not resemble an ordinary hæmatite or other iron ore. It is probably a piece of the "country rock."

2880. Iron ore from the "Stor" Mine, Petersberg, Wermland, Sweden.

This is a massive black ore with a drusy cavity, in which are developed octahedral crystals of magnetite.

2881. Iron ore from Långban Mines, Wermland, Sweden.

A fine grained micaceous hæmatite, with some scattered crystals.

2882. Iron ore from the Stor Mine, Petersberg, Wermland, Sweden.

A massive magnetite with portion of a drusy cavity, showing the mineral in rhombic dodecahedral and trapezohedral crystals.

2883. Iron ore from the Kran Mine, Petersberg, Wermland, Sweden.

Very massive and minutely crystalline.

These ores of Wernland are all referred to the crystalline schists of Archæan age.

2884. Iron ore from Taberg Småland, Sweden, after calcination.

From the Swedish Department, International Exhibition, 1862. The samples have an exterior coating of red solid matter, and within are composed of small black crystals in a dull white matrix. The rock of Taberg is said to be a mixture of magnetite and olivine. *See* Phillips' Ores and Ore Deposits, p. 395.

2885. A series of ores from the Mines of Garpenberg, Wermland, Sweden.

Named after their localities. They are all fine micaceous hæmatites, and are arranged in the order of their coarseness, the most compact being last. 1, Knutsboi Tolkerna; 2, Bispberg No. 2; 3, Orlinge i Norbergsfaita; 4, Rynshytte Sjagrufora; 5, Bispberg No. 1; 6, Holm; 7, Rynshutte Compagne; 8, Langviken.

2886. Bog iron ore from the moors at Axewallsboda, Sweden.

A hydrated peroxide of iron of recent formation.

2887. Lake ore from Lund Lake, Sweden.

A hydrated peroxide of iron formed in lakes of a less depth than 30 feet from ferruginous waters, derived from the decomposition of the neighbouring mass of crystalline hæmatite. It is said to be due to the agency of an infusorian. The ore when first collected is uniformly slimy, but on drying it hardens to lumps of various sizes. The present is called " Penny ore."

2888. Lake iron ore from Yxem Lake, Småland, Sweden.

This is of smaller size when dried, and is called " Bean ore."

2889. Lake iron ore from Yxem Lake, Småland, Sweden.

This hardens into the smallest sized lumps, and is consequently called " Peas ore."

2890. Lake iron ore from Axewallsboda Lake, Astrogathi, Sweden.

This consists of coarse, dark, irregular lumps, found near where the Bog iron ore, No. **2886,** occurs.

2891. Iron ore from Gellivara Lulia, Lapponark, Sweden, lat. 67° 20′.

A massive crystalline rock of coarse isodiametric crystals of magnetite and felspar ? the former far the most abundant.

2892. Iron ore from Gellivara, Lapland.

A schistose variety of the same ore as No. **2891,** with very little felspar. It is said to be titaniferous. These belong to the crystalline schists, presumably of the Archæan period.

2893. Piece of a quartz vein, from the Kron Mine, Petersberg, Wermland, Sweden.

Some of the quartz crystals are coloured black by the magnetite.

2894. Titaniferous iron ore from Egersund, Norway.

Smelted at the Dowlais Iron Works, 1870. A massive, coarsely crystalline rock of bluish-grey colour, between bands of a green silicate.

2895. Lake iron ore from Norway.

Consists of rounded pear-like bodies of dark brown limonite, showing a concentric structure within; contains 36·21 per cent. of metallic iron. Communicated by R. Nesbitt, 1866.

Iron ores from other European countries.

2896. Micaceous iron ore from Elba.

Smelted at the Dowlais Iron Works, 1870. This ore occurs in veins and beds. Of early geological date.

2897. Beach pebbles of hæmatite, collected on the shore at Marina di Rio, Elba.

2898. Iron ores from Russia, locality not stated.

They are brown earthy masses of concretionary limonite; (1) is called Zingary's ore, (2) is Karakuba ore, (3) the same (spelt Carracuba), (4) Dravidsky's brown ore. Communicated by the "New Russia Company," 1873.

2899. Magnetic iron ore sand from Turkey, locality not stated.

It has been assayed by melting 5,000 grains with lime, china clay, &c. and 1,000 grains of anthracite, by which method it yielded a button weighing 3,470 grains. This is equivalent to a per-centage of 69·4 of metal. Some of the grains have an octahedral shape, and all are strongly attracted by the magnet.

Iron ores from Africa.

2900. Natural lodestone from the Cape of Good Hope.

Massive fragments of magnetite of great magnetic strength.

2901. Iron ores from Algeria.

Two are pieces of hæmatite, one is a concretionary limonite, the others are red and dark purple clays. *See* Phillips' Ores and Ore Deposits, p. 515.

Iron ores from the East Indies.

2902. Nodule of earthy brown limonite from Singapore.

Communicated by Dr. Lockhart. Contains 46·64 per cent. of metallic iron.

2903. Iron ore sand from Bandai Salangore, Straits Settlements.

Crystals and fragments of hæmatite, which are not attracted by the magnet, with sand grains intermixed.

2904. Massive black hæmatite in a nodule from near Sairi, the Punjaub, India.

Iron ores from China and Japan.

2905. Earthy brown concretionary massive hæmatite from Rung Chung, China.

Communicated by J. Henderson. Analysed by R. Smith, 1875.

2906. Iron ore from Kai-Ping, China.

A dark hæmatite schist. Communicated by W. Lawford. Analysed by W. J. Ward, 1879.

2907. Three small samples of iron ores from China, locality not stated.

One is a brown concretionary ron ore containing 58·44 per cent. of metallic iron ; the second is a magnetite containing 70·25 per cent. of metallic iron ; and the third is an earthy ochre, yielding a scarlet powder on calcination, and containing 43·20 per cent. of iron. Analysed by R. Smith, 1874.

2908. Mass of crystalline iron "ore" from the neighbourhood of Yeddo, Japan.

This is in small crystals run together, and it cuts like a metal. It is said to be forged direct by the Japanese. Communicated by R. C. May, 1868.

Iron ores from Australasia.

2909. Series of specimens illustrating the purifying of superficial iron ore by the Port Philip Company, New South Wales, Australia.

The material is called "blanket sand." No. 1 is the quartz grains separated by levigation after grinding. No. 2 is the concentrated sand after extraction of the quartz. No. 3 is the same in fine powder, consisting of a mixture of grains of magnetite and of pyrites. No. 4 is the amount of magnetic iron ore attracted by the magnet and thus separated from the rest. No. 5 is the residue of pyrites which is left untouched by the magnet. Communicated by the Port Philip Company, 1862.

2910. Australian iron ore, locality not stated.

A reddish grit, largely composed of crystals of magnetite. Communicated by Fowler & Co., 1874.

2911. Titaniferous iron ore from New Zealand.

It has been fused with charcoal alone in a Cornish crucible. The surface of the melted mass is coated with long acicular crystals which often make their appearance when such ores are assayed in the dry way.

Iron ores from Canada.

2912. Titaniferous iron ore from the Laurentian Rocks of Canada.

It is a black schistose rock. Communicated by Mr. Bullen, 1874.

2913. Another example of titaniferous iron ore, not so crystalline as the last.

Communicated by Mr. Bullen, 1874.

2914. Micaceous iron ore from Nova Scotia.

The hæmatite is in very large lamellar crystals, standing across a vein in a red earthy rock.

2915. Slate used as iron ore from Nictaux, Anapolis Valley Nova Scotia.

These are ordinary masses of Cambrian or Silurian fossiliferous slate, strongly impregnated with ferric oxide.

2916. Bedded hæmatite, McLennan's Mountain, Nova Scotia.

A schistose rock, consisting almost entirely of hæmatite. Communicated by G. M. Dawson, 1873, with the four following specimens.

2917. Limonite from East River, Pictou County, Nova Scotia

A large fibrous mass in several layers of perpendicular crystals.

2918. Specular iron ore from East River, Pictou County, Nova Scotia.

Irregular massive crystalline hæmatite.

2919. Spathic iron ore from Sutherland River, Pictou County, Nova Scotia.

An aggregation of small rhombohedral crystals.

2920. Bedded hæmatite, "Blanchard's," Pictou County, Nova Scotia.

A compact foliated rock.

2921. Bog iron ore from St. Etienne, St. Maurice County Canada.

Small irregular pieces of earthy limonite.

2922. Bog iron ore from St. Marguerite, St. Maurice County Canada.

Irregular concretionary masses of dark and light brown limonite.

Iron ores from America.

2923. Iron ore from the Suckasunny Mine, New Jersey, U.S.A.

This is composed of a mass of fair sized black hæmatite crystals arranged uniformly. It is considered to be the best of the New Jersey ores.

2924. Iron ore from the Suckasunny Mine, New Jersey, U.S.A., containing phosphate of lime.

The crystals in this are smaller, and they are interspersed with green crystals of apatite. These ores form a part of the Archæan schists.

2925. Iron ore from Andover, New Jersey, U.S.A.

These are massive red hæmatite, partly fibrous and partly in large crystals.

2926. Iron ore from Andover, New Jersey, U.S.A.

This is a portion of a banded vein having quartz in the centre and surrounded by fibrous radiating hæmatite.

2927. Hæmatite from Marquette, Michigan, U.S.A.

A black compressed foliated rock. The Marquette deposits have been separated from the Huronian as a distinct group. Communicated by the Jackson Iron Company.

2928. Clay iron ore from Virginia, U.S.A.

A brown banded carbonaceous deposit, containing 32·8 per cent. of metallic iron. Analysed by W. J. Ward, 1875.

2929. Iron ore from Western Virginia, U.S.A.

A tufaceous brown limonite, containing 48·69 per cent. of metallic iron. Communicated by R. J. Carpenter. Analysed by R. Smith, 1873.

2930. Residue from the extraction of zinc from Franklinite (?), smelted for iron at the New Jersey Mining Company's Works, Newark.

A scoriaceous black mass. Communicated by J. Bauerman, 1878.

2931. Franklinite roasted, from the Stirling Works, New Jersey, U.S.A.

The residue, after the zinc has been extracted, used as an iron ore.

2932. Iron chloride from the Little Sliver Mine, Leadville, Colorado.

A scoriaceous mass accompanying silver ores.

2933. Magnetic iron ore with iron pyrites.

The Cornwall ore, Cornwall, Lebanon, Pennsylvania, U.S.A. Shows that even an ore which contains so much pyrites may, after roasting, be smelted with advantage. Communicated by H. Louis.

2934. Laminated form of Gothite, called Lepidokrokite, from a bed of the brown iron ore used at the Glyndon Furnaces, Eastern Pennsylvania.

It is a hydrous oxide of iron, the layers of which are concretionary and have a mammillated and fibrous structure. *See* Dana's System of Mineralogy, p. 170.

2935. Native honeycomb iron ore, smelted at the Dunbar Iron Furnace, Pennsylvania.

A complete analysis of this, which is an argillaceous ore, gives the following :—

Ferrous oxide	45·634
Ferric oxide	2·057
Alumina	3·740
Lime	0·014
Magnesia	1·678
Silica	0·424
Carbonic acid	29·745
Phosphoric acid	0·068
Iron bisulphide	0·754
Combined water	0·042
Hygroscopic water at 100° C.	0·074
Organic matter	1·324
Ignited insoluble residue	15·568
	101·122

The insoluble residue contains silica 10·844, alumina 4·240, lime ·034, magnesia ·439, and traces of ferric oxide. This is equivalent to 35·823 per cent. of metallic iron. Other analysis of the same ore for iron only have shown from 28 to 42 per cent.

2936. Native honeycomb iron ore calcined, smelted at the Dunbar Iron Furnace, Pennsylvania.

This is now a red earthy mass, resembling hæmatite.

2937. Native Big Bottom iron ore, smelted at the Dunbar Iron Furnace, Pennsylvania.

It is a homogeneous massive dark earthy rock, whose analysis shows :—

Ferrous oxide	45·274
Ferric oxide	traces.
Alumina	3 445
Lime	1·456
Magnesia	1·464
Silica	0·195
Carbonic acid	30·322
Phosphoric acid	0·170
Iron bisulphide	traces.
Combined water	0·029
Hygroscopic water at 100° C.	0·003
Organic matter	0·947
Ignited insoluble residue	16·700
	100·005

The insoluble residue contains silica 11·046, alumina 4·697, ferric oxide 0·643, lime 0·264, magnesia 0·047.

2938. Native Big Bottom iron ore calcined, used at the Dunbar Iron Furnace, Pennsylvania.

It is only externally changed to a red colour.

2939. Jackson iron ore from Lake Superior, smelted for Bessemer iron at the Dunbar Furnace, Pennsylvania.

A massive schistose silky red specular ore.

2940. Republic iron ore from Lake Superior, smelted for Bessemer iron at the Dunbar Furnace, Pennsylvania.

A brilliant black micaceous ore. It contains 69·88 per cent. of ferric oxide and 0·01 per cent. of phosphorus.

2941. Champion iron ore from Lake Superior, smelted for Bessemer iron at the Dunbar Furnance, Pennsylvania.

A brilliant black micaceous ore of fine grain. Analysed by Britton gives:—

Metallic iron - - - -	69·92
Oxygen with iron - - -	27·63
Sulphur - - - -	0·04
Phosphorus - - - -	0·01
Lime - - - -	0·52
Moisture - - - -	0·32
Insoluble matter - - -	1·39
	99·83

Of the 69·92 per cent. of iron 22·97 is combined in the ferrous, 46·95 in the ferric state.

2942. Washington iron ore from Lake Superior, smelted for Bessemer iron at the Dunbar Furnace, Pennsylvania.

A very fine micaceous ore, said to be magnetic. Analysed by Britton gives:—

Metallic iron - - - -	68·46
Oxygen with iron - - -	27·22
Phosphorus - - - -	0·01
Lime - - - - -	0·14
Moisture - - - -	1·19
Insoluble matter - - -	2·60
	99·62

Of the 68·46 per cent. of iron 19·30 is combined in the ferrous, 49·16 in the ferric state.

2943. Iron Mountain magnetic iron ore, smelted at the Dunbar Furnace, Pennsylvania.

Coarse irregularly crystallised and black, containing on the average 60·68 per cent. of metallic iron.

2944. Chaffey iron ore, smelted at the Dunbar Iron Furnace, Pennsylvania.

Coarse, black and crystalline, having the following composition :—

Magnetic oxide - - -	60·57
Ferrous oxide - - - -	10·03
Alumina - - - -	3·69
Lime - - - - -	0·61
Magnesia - - - -	4·96
Silica - - - - -	7·08
Phosphoric acid - - -	trace
Sulphur - - - -	0·82
Titanic acid - - - -	11·43
	99·19

This is equivalent to 52·36 per cent. of metallic iron.

2945. "Mill cinder" used as an ore for smelting at the Dunbar Iron Furnaces, Pennsylvania.

It is a black scoriaceous refinery slag, from the mills.

2946. Lodestone or magnetic iron ore from Brazil.

2947. Micaceous iron ore from Itabira, Minas Geraes, Brazil.

A schistose rock almost entirely composed of hæmatite spangles.

2948. Concretionary iron ore from Para, Brazil.

A sandstone infiltrated with hydrated ferric oxide.

IRON ORES FROM UNKNOWN LOCALITIES.

2949. Crystalline magnetic iron ore.

Analysed by C. Tookey. Contains 38 per cent of metallic iron, and 1·31 per cent. of sulphur. Communicated by Mr. Appleton.

2950. Massive earthy brown hæmatite.

Communicated by Mr. Taylor.

2951. Oolitic iron ore.

A brown hæmatite, containing 28·02 per cent. of metallic iron. Communicated by the Earl of Ilchester. It looks like the Westbury ore.

2952. Fibrous black hæmatite, developed on a massive piece and showing a stalactitic development of hæmatite on the smooth surface.

2953. Black oolitic iron ore.

Analysed by Dr. Percy for Mr. Blackwell. Is it Welsh pisolite ?

2954. Compact Ilmenite.

Titaniferous iron ore. Communicated by Mr. Burchell, with two tubes of materials derived from it.

2955. Magnetic iron ore.

Communicated by Mr. Arundel, 1870. Analysed by C. Tookey.

Ferrous oxide	36·13
Ferric oxide	20·00
Manganous oxide	·06
Alumina	9·20
Lime	3·20
Magnesia	1·32
Phosphoric acid	2·02
Sulphur	0·04
Water	7·31
Organic matter	·30
Insoluble residue	20·17
	99·75

Equivalent to 42 per cent. of metallic iron.

2956. Spathose iron ore with a border of pyrites.

2957. Specimen resembling spathic iron ore, but containing only 6·11 per cent. of metallic iron. Analysed by R. Smith.

FALSE IRON ORES.

2958. Oxide of iron conglomerate.

From Toddington Manor, Dunstable, Kent. It forms a thin bed about three feet from the surface and consists of siliceous pebbles imbedded in a matrix of limonite. As analysed by R. Smith, it contains 20·42 per cent. of metallic iron. Communicated by Major C. Cooper.

2959. Supposed iron ore from the New Forest, Hampshire.

Two specimens derived from the Upper Eocene series. One is a compact sandstone impregnated with brown hæmatite. The other is a slaggy mass containing abundant fragments of charcoal, probably an attempt at smelting. The metallic iron obtainable from the sandstone amounts to 16·24 per cent.

2960. "Iron ore" from Providence, Ashton Court, Bristol.

An analysis of this has been given as silica 22·25, oxygen 23·20, and iron 54·55, but this has been found by J. Spiller to be erroneous.

2961. Mass of red clay, locality unknown, sent as a sample of iron ore.

On examination it is found to contain only 3½ per cent. of metallic iron.

2962. Specimen sent as spathic iron ore from East Tarbert, Lochfyne, Argyleshire.

It consists essentially of carbonate of lime and contains only 1½ per cent. of metallic iron.

2963. Limestone sent as spathic iron ore from Bonnsville Court, Saundersfoot, Pembrokeshire.

It contains only 1·52 per cent. of metallic iron.

2964. So called "argillaceous iron ore" from the Lias.

From near Middlesborough. It consists of a bed of clay showing cone in cone structure with a certain small amount of iron.

2965. Cement-stone nodule containing iron and mistaken for an ironstone.

It is used for making Roman cement of the best quality and is called the screw or bastard stone, near Darlaston. Communicated by Mr. Clift.

2966. Material from Tioga, New York, said to have wonderful powers in the manufacture of steel, &c.

It is nothing but some red micaceous shale of no value whatever.

THE PRODUCTION OF PIG IRON.

MATERIALS USED AS FLUXES.

2967. Limestone used in the blast furnace at Finspong, Ostgothland, Sweden, with the Swedish iron ores.

A white crystalline limestone. Compare Percy's Metallurgy, Iron and Steel, p. 553.

2968. Limestone used as a flux in the Allentoun Furnace, on the Lehigh River, Eastern Pennsylvania.

A black compact marble.

2969. Limestone used at Newland Furnaces, Ulverstone.

Grey compact Carboniferous Limestone of Lancashire.

2970. Limestone used at Ystalyfera, South Wales.

The dark grey Carboniferous Limestone of South Wales.

2971. "Coal limestone" used as a flux in smelting iron at the Dunbar Iron Furnaces, Pennsylvania.

Analysed by Habershaw. Gives—

Calcium carbonate	86·58
Magnesium carbonate	3·71
Ferric oxide and alumina	6·25
Silica	0·76
Organic matter	0·21
Insoluble	2·83
	100·34

2972. "Mountain limestone" used as a flux in smelting iron at the Dunbar Iron Furnaces, Pennsylvania.

Analysed by Maynard and Van Rensselaer. Gives—

Calcium carbonate - - -	87·69
Magnesium carbonate - - -	2·76
Ferric oxide and alumina - -	1·13
Insoluble - - - - -	7·46
	99·04

SLAGS PRODUCED IN THE MANUFACTURE OF PIG IRON.

Non-crystalline slags.

2973. Slag from Gartsherrie blast furnaces.

It is produced in a hot-blast furnace, manufacturing the best quality (No. 1) of pig iron. It is compact internally, and has a coat of grey glass.

2974. Blast furnace slag; from a hot-blast furnace, making good rail iron at the Cyfartha Works, South Wales.

Communicated by D. Wilson, 1871. A black glass, with narrow bands of white, which are bent round into a fold, and drawn out by the motion of the molten mass, after the manner of a lava current.

2975. Blast furnace slag from Bromford Iron Works.

An olive green, glassy mass, but with bands and scattered individuals of lighter tinted tetragonal prisms.

2976. Blast furnace slag from the Ystalyfera Iron Works, South Wales.

Produced with anthracite as fuel; a brown earthy-looking mass, which becomes a black glass at the surface, where it contains isolated light coloured tetragonal prisms.

2977. Blast furnace slag, produced from spathic ores at the Ebbw Vale Iron Works, South Wales.

Communicated by G. Parry, 1859. Green glassy masses of two distinct tints, light and dark, sharply marked off from each other, and both with abundant contorted flow lines.

2978. Black slag, produced when a furnace (locality unknown) was deranged.

The derangement was due to some interruption in the descent of the material in the blast furnace, as observed at the top, and its subsequent dropping suddenly on the twyers, as seen by the sudden fall of the surface. It is a black compact mass, with a brilliant black glassy surface. The iron made was white iron.

2979. Slag from a London iron foundry.

Communicated by J. C. Crosson, 1876. A scoriaceous mass with smooth undulating glassy surfaces.

2980. Scoriaceous, semi-crystalline, dark-grey slag, produced from one-third Eston, and two-thirds Weardale, iron ore.

7½ cwt. of Weardale and Eston ores were smelted with 4 cwt. of coke, and 2⅛ cwt. of limestone.

2981. Iron slag, containing titanic acid. No. 1.

A black, semi-crystalline, scoriaceous mass; locality not stated. Compare Percy's Metallurgy, Iron and Steel, p. 507.

2982. Iron slag with titanic acid. No. 2.

A thin sheet, slightly scoriaceous in the centre, but becoming compact and grey, and at the edges more glassy and blue. Compare Percy's Metallurgy, Fuels, 1875, p. 56.

2983. Iron slag with titanic acid. No. 3.

Dark and semi-vitreous.

2984. Lavender-coloured blast-furnace slag, from Russell Hall's furnaces, near Dudley.

The slag is compact, and the lavender colour is interspersed with green, and is spotted over with minute black specks or hollows.

2985. Pink-coloured blast-furnace slag from Ebbw Vale Iron Works.

Communicated by Mr. Parry, 1859. It is uniformly coloured, and very finely scoriaceous, and light like a pumice. Said to be produced when the charge has contained much spathic ore. *See* Percy's Metallurgy, Iron and Steel, p. 506.

2986. Pink-coloured iron slags found on the road near Pontypool Iron Furnaces, South Wales. (Three specimens.)

Two of these are scoriaceous, with large vesicles, and on breaking them across to obtain a fresh surface, it is seen that the pink colour is merely superficial, and that the slag is green within. The second specimen shows a green compact interior and a coating of pink; the third is more glassy, and is bluish in the interior. It appears, therefore, that the pink colour is the result of superficial alteration or weathering.

2987. Pink-coloured slag from the Dowlais Iron Works, South Wales.

Communicated by E. Riley. These are fragments of glassy slags which once were blue, but now shade through green to pink on the surface. The colour may depend on the presence of manganese in the slag.

2988. Pink-coloured blast-furnace slag from the Glengarnock Iron Works, 1885.

A scoriaceous mass, probably weathered to the centre.

2989. Blast-furnace slag produced when making No. 1 iron, (No. **3179** of this catalogue), at the Newland Furnaces, Ulverstone, 1856.

A dark purplish translucent glass with feeble signs of the flow of the molten material. This and the five following were communicated by Mr. Roper.

2990. Blast-furnace slag produced when making No. 3 iron at the Newland Furnaces, Ulverstone.

A bluish, translucent, solid glass with a slight tinge of green on the surface.

2991. Blast-furnace slag produced when making No. 2 iron at the Newland Furnaces, Ulverstone.

Two specimens, one is a compact bright blue non-translucent mass, with fine pin holes, and a darker blue more glassy margin. The other is a cindery mass from the surface, with some unaltered scales of hæmatite imbedded. It is a transparent glass with floating blue particles of brilliant tint. Compare Percy's Metallurgy, Fuels, 1875, on the blue colour of slags.

2992. Blast-furnace slag produced when making No. 5 iron at the Newland Furnaces, Ulverstone.

A black vitreous froth, with large and small cavities, excessively light.

2993. Blast-furnace slag produced when making No. 6 iron at the Newland Furnaces, Ulverstone.

A light scoriaceous black mass, most glassy and with the largest cavities on the outside portions, one of which contain bits of charcoal, &c. Produced in the refinery ?

2994. Blast-furnace slag produced in making No. 6 iron at the Newland Furnaces, Ulverstone.

A greenish black opaque glass with a scoriaceous surface.

2995. Slag from No. 6 iron at the Newland Furnaces, Ulverstone.

A solid heavy regulus-like mass with a glassy surface with imbedded gravel. The iron made was unsaleable. *See* No. **3183.**

2996. Black glassy slag in small irregular fragments.

Communicated by Mr. Dalton.

2997. Blast-furnace slag from the Cyfartha Iron Works, South Wales.

A very uniform clear brown glass.

2998. Blast-furnace slag from the Cyfartha Iron Works, 1889.

An opaque grey stone changing towards the surface, through a blue tint to a dark glassy banded layer.

2999. Blast-furnace slag from the furnace casting in 1851, at a time that three qualities of iron were obtained.

Scoriaceous below, green, compact in the centre, dark green and glassy on the top.

3000. Blast-furnace slag showing an iridescent surface.

A thin greenish opaque glass with a broad smooth surface, locality unknown, two specimens.

3001. Blast-furnace slag with iridescent particles on its surface.

A piece of green opaque slag probably from the same furnaces as the last, partly glassy and partly crystalline. The iridescence is confined to the glassy portion and dies away as it passes with the crystalline.

3002. Uniform black glassy blast-furnace slag, produced in smelting Ashton iron ore at Dowlais, South Wales.

Communicated by E. Riley.

3003. Vesicular slag from the blast-furnaces at Russell Hall's Iron Works, Dudley, 1861.

A honeycombed brown-coloured mass, presumed to be formed by the occlusion of air by the molten slag which separates but cannot escape on the solidification. *See* Percy's Metallurgy, Fuels, 1875, p. 55.

3004. Vesicular green slag from the blast-furnaces at the Newland Iron Works, Ulverstone.

The cavities are almost always separated by some thickness of the green semi-vitreous slag. The green colour is said to be due to the presence of manganous oxide. Communicated by E. Riley.

3005. Pumice-like blast-furnace slag from the Blaina Iron Works, South Wales.

It is perfectly white and contains larger and smaller holes. It is called "Furnace pumice" and is produced by the slag coming in contact with water while in a molten state by which means steam is generated in its midst. *See* Percy's Metallurgy, Iron and Steel, p. 516.

3006. Blast-furnace slag showing a columnar structure.

Communicated by J. Blair, 1886. This was produced many years ago at the Wingerworth Iron Works, Chesterfield, in smelting oolitic ores, but the details of the circumstances are not on record except that the furnace was "gobbed" at the time. The analysis gives—

Silica - - - - -	29·70
Alumina - - - -	22·00
Lime - - - - -	46·53
Manganous oxide - - -	trace
Magnesia - - - -	1·50
	99·73

The column is pentagonal, with concave sides, and the whole has a semi-vesicular lava-like texture.

3007. Blast-furnace slags from smelting manganese ores to make spiegeleisen. From the furnaces of Sir J. Brown & Co., Sheffield.

Some of these are of an olive green opaque glass, one is coated with a layer of dark brown transparent glass, one is more or less compactly crystalline, and one has drusy cavities in which are long prismatic needles resembling ferro-manganese.

3008. Slag from off the surface of the molten iron in smelting Ashton iron ore.

This ore contains barytes. It was smelted at Dowlais Iron Works, and this material ran out on the top of the pig and must have lain between the ordinary cinder and the molten pig. It contains sulphides. Communicated by E. Riley. It has been analysed by R. Smith and found to contain 69·10 of sulphide of iron, 20·28 of barium sulphide, and small quantities of calcium, magnesium, potassium, sodium and manganese, and 0·08 of copper. *See* Percy's Metallurgy, Iron and Steel, p. 895.

3009. Blast-furnace slag from the ironworks of Seend, Wiltshire.

They smelt oolitic ore here. It is a bluish green opaque glass with scattered black spots of semi-crystalline slag. Communicated by H. Bauerman, 1875.

3010. Slag which collects in the Cowper hot-blast stoves, when the furnaces are making spiegeleisen. At Sir J. Brown & Co.'s Iron Works, Sheffield.

Communicated by J. Blair. The ore used was Spanish. It is an opaque brown glass and has been analysed by W. Galbraith and shown to contain—

Zinc oxide	18·66
Ferrous oxide	2·57
Manganous oxide	6·97
Alumina	10·03
Potash	17·80
Soda	9·80
Silica	34·10
	99·93

Associated with it was some zinc dust containing 2·23 per cent. of potash and 1·20 per cent. of soda.

3011. Slag from No. 3 blast furnace at Ebbw Vale when making spiegeleisen.

The spiegeleisen produced contained about 16 per cent. of manganese. This slag is green, semi-crystalline, and compact. It contains a number of crystals in the form of tetragonal prisms. They are lighter in tint and have cracks along the diagonals, with a hollow in the centre, like the crystals of chiastolite. Communicated by G. Fitz-Brown.

Foreign Slags.

3012. Blast-furnace slag produced in making Bessemer pig iron at the Royal "Marienhütte" Iron Works, Germany.

Communicated by G. F. Becker. These are produced when the furnace is working well and smelting a mixture composed of 65 per cent. of spathic iron ore, 25 per cent. of manganiferous hæmatite, and 10 per cent. of siliceous hæmatite. The slag is allowed to cool slowly in large iron boxes, in which cavities are formed lined with a pink, often crystalline coating, the main mass having a green tinge.

3013. Foundry-furnace-slag produced at the Royal "Marienhütte" Iron Works.

Communicated by G. F. Becker. This is a product of smelting 25 per cent. of minette (*i.e.*, Luxemburg oolitic ore), 25 per cent. of bog iron ore, 30 per cent. of calcareous hæmatite, and 20 per cent. of sphærosiderite. These are of the same colours as the Bessemer slag, but more compact and less crystalline.

3014. Highly porous grey slag from the iron furnaces of Holland.

Definite locality not given. It is almost like pumice, with a glassy surface, and is produced in the smelting of the ore No. **2845.** Communicated by J. E. de Fry.

3015. Blast-furnace slag from the iron furnaces called "Herzog-auguste Hutte," Dillenburg, Nassau.

A glassy mass, with a stony under surface, with pieces of charcoal showing the nature of the fuel employed. The surface is marked by the flow of the semi-liquid mass.

3016. Blast-furnace slag from the "Herzog-auguste Hutte" furnaces, Dillenburg.

It is a banded black glass, with scattered rectangular prisms of a grey colour.

3017. Another basic slag similar to the last, but without label.

3018. Blast-furnace iron-slag from the United States

Black on one side, where it is scoriaceous; yellowish grey on the other, where it is confusedly crystalline.

3019. Blast-furnace slag from Allentoun furnace.

A solid, grey, stony mass, with rectangular prisms in parts of the surfaces; lustre of the faces dull.

3020. Blast-furnace slag, locality uncertain.

It consists of a brilliant black glass, in which are embedded isolated grey spherulites with radiate crystallisation so coarse that sections look like corals.

3021. Blast-furnace slag from smelting ores containing titanium at Espedal, Norway.

Communicated by D. Forbes. A porous, semi-crystalline, stony mass, of brownish tint; rapidly becomes quite compact, but has a black glass on the surface.

3022. Slag from a blast-furnace using charcoal as fuel, in Poland.

A completely vitreous, coarsely vesicular, black mass. Analysed by W. J. Ward. It contains 7·56 per cent. of ferrous oxide, 29·58 per cent. of aluminia, 52·67 per cent. of silica, 4·52 per cent. of lime, and 1·27 per cent. of manganous oxide. This is equivalent to a loss of 5·88 per cent. of metallic iron.

3023. Slag from the blast-furnaces of the Northern Iron Company, Marquette, Michigan, U.S.A.

A homogenous, black, slightly translucent glass.

3024. Banded slag from the blast furnaces of the Northern Iron Company, Marquette, Michigan.

Black below and white above, with flow lines of the latter colour dying out in the former, the whole glassy.

3025. Pumiceous slags from the blast-furnace of the Northern Iron Company, Marquette, Michigan.

One side is perfectly glassy and black, but it rapidly changes into a white pumiceous mass, where it has been brought into contact with water.

3026. Blast-furnace slag from the Wyandotte furnaces, Detroit.

A black, slightly mottled, homogeneous glass, quite translucent.

3027. Blast-furnace cinder from Sweden.

A light greenish opaque glass, with aggregations of black semi-crystalline slag.

3028. Slag from a Swedish iron blast-furnace. From the International Exhibition, 1862.

It is greenish grey, compact, and spherulitically crystalline within, and suddenly changes with an irregular boundary to a translucent green glass on the surface. It has flowed over cinders.

3029. Blast-furnace slag from the ironworks of Finspong, Sweden.

Communicated by C. Eckman. A leak-green, opaque, vitreous mass, spotted with black, and darker green on the surface. The charge which is used in these furnaces, which are employed in the manufacture of iron for cannon, is given in Percy's Metallurgy, Iron and Steel, p. 553, by which it appears that the ores used are very manganiferous, hence the green colour.

3030. Iron-slag from the Province of Borgarfjordr, in Iceland.

Communicated by Dr. Hjaltelin, of Reykjavik. Found near the Surturbrands beds, which are of Miocene age. It is made from a very ferruginous basalt, which till recently has been worked in Germany for iron. It is a black mass of superimposed flows of molten matter, with large cavities, and of compact substance.

3031. Slag from a furnace making spiegeleisen at Mulheim, on the Rhine.

Communicated by H. Bauerman. The slag is made with 50 per cent. of limestone in the charge, and has disintegrated spontaneously on cooling.

3032. Slag from working No. 2 iron at the New Jersey Zinc Works, Newark, U.S.A.

As this has the colour of spiegeleisen slag, and as spiegeleisen is produced at these works, this appears to be the slag of the same. It is a dark brown glass, touched with green.

3033. Slag from the spiegeleisen-furnace of the New Jersey Mining Company, Newark, New Jersey, U.S.A.

Communicated by J. Bauerman, 1871. An opaque, green glass, becoming crystalline in parts.

Crystalline Slags.

3034. Basic slag from a hot-blast-furnace working with coke, near Dudley, South Staffordshire.

This is the No. 1 of the Report on Crystalline Slags presented by Dr. Percy to the British Association in 1846, and the No. 2 of the "Slags of the Formula $R^2O^3\ SiO^3 + 2\ (3\ RO\ SiO^3)$" of his Metallurgy, Iron and Steel, p. 497. It consists of transparent, square, tabular crystals, which have the following composition. Analysis by Dr. Percy.

Silica	38·05
Alumina	14·11
Lime	35·70
Magnesia	7·61
Manganous oxide	0·40
Ferrous oxide	1·27
Potash	1·85
Calcium sulphide	0·82
	99·81

3035. Basic slag from a hot-blast-furnace working with coke, near Dudley, South Staffordshire.

This is No. 2 of the Report, and No. 3 of Percy's Metallurgy, Iron and Steel, p. 497. It consists of similar transparent tabular prisms, and has the following composition. Analysis by Dr. Percy.

Silica - - - -	38·76
Alumina - - - -	14·48
Lime - - - - -	35·68
Magnesia - - - -	6·84
Manganous oxide - - -	0·23
Ferrous oxide - - -	1·18
Potash - - - -	1·11
Calcium sulphide - - -	0·98
	99·26

3036. Basic slag from a hot-blast-furnace, Russell Hall.

This is No. 3 of the Report above referred to, and No. 4 of Percy's Metallurgy, Iron and Steel, p. 497. The specimens show highly crystalline, black, square tables in drusy cavities, some of which have the angles truncated as described. These slags are said to have the following composition. Analysis by Dr. Percy.

Silica - - - -	37·63
Alumina - - - -	12·78
Lime - - - -	33·46
Magnesia - - - -	6·64
Manganous oxide - - -	2·64
Ferrous oxide - - -	3·91
Potash - - - -	1·92
Calcium sulphide - - -	0·68
	99·66

3037. Basic slag from Messrs. Blackwell's-hot-blast furnaces, working with coke. Russell Hall's Iron Works, Dudley, South Staffordshire.

This is No. 4 of the Report above referred to, and No. 5 of Dr. Percy's Metallurgy, Iron and Steel, p. 497. It consists of a compact crystalline mass, showing opaque, greenish prismatic crystals on the surface. These are not transparent, but show clear signs of being complex growths. It is possible that this (though labelled with a figure) may be wrongly identified. The analysis given, made by D. Forbes, is—

Silica - - - - -	37·91
Alumina - - - -	13·01
Lime - - - - -	31·43
Magnesia - - - -	7·24
Manganous oxide - - -	2·79
Ferrous oxide - - - -	0·93

Potash	2·60
Calcium sulphide	3·65
	99·56

3038. Basic crystalline slag, very similar to the last.

This is unlabelled. It is more crystalline, the centres of the crystals being often transparent. With this exception the whole is well shown to be composed of complex crystals, some of which show with perfect clearness the black cross characteristic of chiastolite.

3039. Cold-blast-furnace slag from Phillip Williams' Iron Works, Wednesbury Oak, Tipton, Staffordshire.

This is No. 5 of Dr. Percy's British Association Report, and No. 1 of his Metallurgy, Iron and Steel, p. 497. This is very crystalline on the surface, the crystals being prismatic plates, overlapping and united. The analysis by D. Forbes gives—

Silica	39·52
Alumina	15·11
Lime	32·52
Magnesia	3·49
Manganous oxide	2·89
Ferrous oxide	2·02
Potash	1·06
Calcium sulphide	2·15
	98·76

3040. Glassy variety of the same slag as the last, showing the isolation of the crystals in the glass.

3041. Blast-furnace slag from a hot-blast-furnace working with coke, from La Providence Iron Works, Marchienne Charleroi, Belgium.

Communicated by S. H. Blackwell. This is No. 6, both in the Report above referred to and in Percy's Metallurgy, Iron and Steel, p. 497. It is dark brown, vacuous, half glassy, half crystalline ; the crystals are indeterminable. The analysis by Dr. Percy gives—

Silica	42·06
Alumina	13·05
Lime	32·53
Magnesia	1·06
Manganous oxide	2·26
Ferrous oxide	4·94
Potash	2·69
Calcium sulphide	1·03
Phosphoric acid	0·19
	99·81

3042. Intermediate blast-furnace slag from the Russell Hall's Furnaces, near Dudley, South Staffordshire.

It is very tough, and consists of an agglomeration of small radiating crystalline masses, of a light yellowish brown colour. Analysed by A. Dick, giving—

Silica - - - - -	47·08
Alumina - - - -	12·91
Lime - - - - -	29·92
Magnesia - - - -	4·79
Ferrous oxide - - - -	1·00
Manganous oxide - - -	2·20
Potash - - - -	·87
Calcium sulphide - - -	1·78
Phosphoric acid - - -	0·05
	100·60

From this it is deduced that the formula of the crystals is "$R^2 O^3$, $Si O^3 + 3 (Ca O Si O^3)$."

3043. Intermediate slag from the hot-blast-furnaces of L'Espérance, Seraing, Belgium.

Communicated by S. H. Blackwell. This is No. 11 in Dr. Percy's Report to the British Association, 1846, on Crystalline Slags. It is a brown vacuous mass, with confused interlacing crystals. Analysed by D. Forbes, and gives—

Silica - - - - -	55·77
Alumina - - - -	13·90
Lime - - - - -	22·22
Magnesia - - - -	2·10
Manganous oxide - - -	2·52
Ferrous oxide - - - -	2·12
Potash - - - -	1·78
	100·41

This approximates it to the formula, $Al_2 O_3 Si O_2 + 4 Ca O 3 Si O_2$. *See* Percy's Metallurgy, Iron and Steel, p. 501.

3044. Blast-furnace slag, approximating to Gehlenite in composition, from the hot blast furnace of Oldbury, near Birmingham.

It is mixed with pieces of coke and iron, and consists of three square crystalline tables of a white and transparent colour, with particles of sulphur here and there on their surface. This is No. 7 of the Report above referred to. Analysed by Dr. Percy it gave—

Silica - - - - -	28·32
Alumina - - - -	24·24
Lime - - - - -	40·12
Magnesia - - - -	2·79
Manganous oxide - - -	0·07
Ferrous oxide - - - -	0·27

Potash - - - -	0·64
Calcium sulphate - - -	0·26
Calcium sulphide - - -	3·38
	100·09

This approximates it to the formula "$3\,Al^2\,O^3\,Si\,O^3 + 3(3\,Ca\,O, SiO^3)$." It is the original specimen of artificial Gehlenite referred to in Dana's System of Mineralogy. *See* Percy's Metallurgy, Iron and Steel, p. 502.

3045. Crystalline slag, locality unknown.

A blue glassy mass below, with greenish-grey, semi-opaque crystals, like those of No. **3037,** forming a surface layer. They are square prisms, with pyramidal ends, standing perpendicularly to the surface of the slag.

3046. Coarsely crystalline surface of a slag, locality unknown.

Below, this is composed of similar crystals to those of the last, but here the surface is covered with a dark coating, and shows crystals $\frac{3}{4}$ in. in diameter of opaque greenish substance within, and of an octagonal prismatic shape with convex sides and complex in growth.

3047. Crystalline surface of a slag, showing an ingrowth of greenish opaque material from the four sides of a tetragonal prism having a dark centre as in chiastolite.

3048. Dark grey glassy slag, with scattered crystals of opaque yellowish-green material, apparently in rhombic prisms.

(Labelled 8A, but not corresponding in description to No. 8, of Dr. Percy's Report.)

3049. Mass of greenish grey slag, no locality.

This shows a surface with the ends of light coloured tetragonal prisms imbedded in a darker substance, and with a hollow in the centre of each. On the other side the crystals interlace confusedly.

3050. Similar mass of slag, with the intervening matrix in places of a deep purple blue.

3051. Piece of the deep purple-blue matrix alone, showing a few of the lighter greenish crystals in the centre.

3052. Piece of blast furnace slag, showing layers of different characters, no locality.

At the base it is deep blue and compact, then it changes to yellowish green, then to brownish green, becoming more crystalline and darker in tint from the inside to the outside. The crystals show complex structure and are rhombic or tetragonal and semi-transparent.

3053. Blast-furnace slag, crystallised in the form of augite, locality unknown.

The crystals are black and interlace, leaving interspaces. They are complex prisms, having the form of augite (Miller). Communicated by Mr. Holmes.

3054. Blast-furnace slag, showing radiating crystallisation, from Dowlais Iron Works.

This is a black heavy mass, porous on one side with drusy cavities, with fibrous crystals aggregated in sheaths. It has been analysed by G. J. Snelus, and has the formula R_2O_3, $SiO_2 + 2\ (3RO, Si\ O_2)$.

3055. Crystalline slag, showing radiating structure, locality unknown.

The crystals are black, and radiate from various points, like spheroids.

3056. Group of crystalline slags from the blast-furnaces of the Aberdare Iron Works.

Communicated by David Price. One of these contains drusy cavities, in which are abundant black radiating crystals, pyramidal at the end, and with aborescent side-branches at angles of about 60°. Another has the crystals more compact and forming on the outside convex hexagons like those of calcite and in one place a perfect hexagonal prism. The others are intermediate and show a very grey colour on the fresh surface.

3057. Series of Gehlenite slags from iron works at Falkirk, N.B.

Communicated by H. Aitken, 1885. These were produced in making some large blocks of slag, from 12 to 15 tons, and are very unusual. *See* No. **3044.** There are five pieces from different parts of the mass. That from near the centre is greyish green, and compactly crystalline, closely resembling a sanidine trachyte. This has been examined by A. Dick. That towards the centre from the bottom has large crystals, consisting of flat tables with outgrowths. The portion near the top is a complete network of such tables, having many intervening spaces. They are of greyer tint than the central mass. The other pieces near the "scurf" are similar in character but more compact. This portion has been analysed by E. Jackson. *See* Bauerman, Proc. Iron and Steel Institute, 1886.

3058. Blast-furnace slag resembling Gehlenite.

Part of this consists of short prismatic crystals with intervals between and part of closely set interlacing lamellæ. Analysed by E. Jackson. This specimen shows the junction of the two varieties.

3059. Blast-furnace slag from the Olsberger furnaces on the Rhine.

Obtained from M. Krantz. It shows some oblique prisms in the drusy cavity on one side, one of which appears twinned from having adjacent faces equal in parts, though elsewhere it is scoriaceous. It is the No. 9 of Dr. Percy's Report on Crystalline Slags to the British

Association in 1846, p. 362. The mean analysis there given, made by Dr. Percy, is—

Silica	53·37
Alumina	5·12
Lime	30·71
Magnesia	9·50
Manganous oxide	1·41
Ferrous oxide	0·95
	101·06

See also Percy's Metallurgy, Iron and Steel, p. 501, where the slag is said to approximate to aluminiferous augite in composition.

3060. Blast furnace slag from the Olsberger furnaces on the Rhine.

Obtained from M. Krantz. It shows short pyramidal oblique crystals confusedly intergrown. It is No. 10 of Dr. Percy's British Association Report on Crystalline Slags, p. 363. The analysis by D. Forbes shows—

Silica	53·76
Alumina	4·76
Lime	29·48
Magnesia	9·82
Manganous oxide	1·30
Ferrous oxide	1·48
	100·60

There is a little graphite on one side.

3061. Spiegeleisen-slag showing crystals. From J. Brown & Co.'s Furnaces, Atlas Works, Sheffield.

Communicated by T. Blair, 1876. The slag was made while working a siliceous ore with a deficiency of limestone in the charge. The crystals are greenish and hopper shaped, they form tetragonal prisms with their corners truncated at 45°. In one specimen they are tabular and brown. They occupy drusy cavities in a compact crystalline green mass, containing perforated crystals as in No. **3011.** Accompanying this is a brown transparent glass with a green coating. The crystals have been partially analysed by T. Blair, and contain silica 33·45 per cent., alumina 15·70, lime 20·97, manganese oxide 21·12, magnesia 2·67, and sulphur 2·37 per cent.

3062. Blast-furnace slag showing in the cavities small brown mica-like plates, locality unknown.

3063. Crystallised blast-furnace slag from Elswick Iron Works, 1868.

This is a compact rock-like mass of greenish-grey colour, composed of closely fitting, irregularly placed tetragonal prisms with dark centres.

3064. Compact and crystalline slags from the neighbourhood of Charleroi, Belgium.

One from Marchienne is massive with glassy selvages, another is black, feebly porous, and from Cuillet, with radiating crystals in hollow spaces within, another from the same spot is still more crystalline, approaching No. **3055,** and one has a black glass selvage and an equally crystalline mass within one inch of it.

3065. A series of crystalline slags from the blast-furnaces of the South Easton Iron Works, Easton, Pennsylvania.

Communicated by Edward Swift, 1853. They are produced in a large stack 12 ft. in diam. by 35 ft. high, working with anthracite and smelting the brown hæmatite of the neighbourhood mixed with the magnetic ore of Morris County, New Jersey. The slag was cast into pools about 4 ft. wide and 12 to 15 in. deep. The crystals were developed in most of those masses which were allowed to cool undisturbed. Their formation ceased when the slag was run into one or one and a half ton blocks. These slags are greenish-grey in colour, compact and rock-like within, and the crystals are developed on the surface of drusy cavities, some of these cavities have each more than a foot in diameter at the works. The crystalline portion is accompanied by some purple blue, semi-vitreous material, like Nos. **3049, 3050,** which may very probably come from this locality. The crystals have been mostly examined by Prof. W. H. Miller. The specimen labelled A. is half brown, half blue, "it exhibits the forms 111 h h k of the rhombohedral "system, the faces are covered with a coating that renders the measure-"ment of the angles impossible." They show truncated and also double hexagonal pyramids or scalenohedra. B. The crystals are "not "capable of measurement, being covered with a fused coating, the "greater part consists of crystals of the prismatic system. Exhibiting "the faces 001, 110. There are also a very few crystals probably of "the oblique system of lighter colour than the former. Possibly these "crystals may belong to the prismatic system." The former of these consist of parallelopipeds, actually with oblique angles, and with highly curved faces, the latter are double, actually oblique, rhomboidal pyramids. C. Shows "rhombohedral crystals, they exhibited the faces 111 and "either 011 or $2\bar{1}\bar{1}$." These are the same truncated or double hexagonal pyramids, or scalenohedra as in A. D. "Shows crystals of "the pyramidal system, exhibiting the faces of the forms 001 100, "the faces are not bright enough to afford a measurement." This is a more stony mass with no glass observable, and of a dull grey (neither the green nor blue) colour. The crystals are rectangular prisms of complex origin. Of the smaller crystals, E. "is not measurable . . . "probably pyramidal," it consists of the interlacing flat tabulæ like those of No. **3057,** the main mass of the stone is a greyish-blue and is all crystalline: F. consists of radiating crystals starting from various points as in No. **3055,** some individuals are seen to be very flat double rectangular (?) pyramids as in B. of a light grey colour: G. of similar radiating structure, the crystals are either "prismatic or pyramidal" (Miller). They consist of the same tabulæ, actually rectangular but not square, some with flat surfaces truncating the pyramids: H. another example of the same character; Prof. Miller "thinks it is prismatic": I. a specimen of the same kind showing more perfect crystals of the "prismatic system." Some of these are perfect rhombs, others consist of a combination of a dome and an octahedron forming hexagonal outlines, others again have the apex truncated by a basal plane, forming rather thin plates: J. the same kind of crystal radiating from the same surface to which a coating has been formed: K. small crystals of the same group as A. and C., *i e.* of "the rhombohedral system but the angles cannot be measured" (Miller). They are double hexagonal prisms, some of which are truncated by basal planes, others by hexagonal prisms. These stand out on one side of a mass of which the other side is highly scoriaceous: L. black crystals, actually rectangular parallelopipeds, with curved faces, some of which look flatly pyramidal, "they may be figures of the cubic system, "of the form (h k 0)"; these are like B.: M. grey square tabulæ, which are rough, like pseudomorphs, hence they belong to the "pyramidal system "but are not measurable" (Miller). It does not appear that all these varieties came from the same mass, but there is no indication from which each came.

3066. Crystalline blast-furnace slag from Rubeland, Harz?

Bright grey-brown interlocking plates with intervals between. Pieces of charcoal are imbedded on the other side.

3067. Grey crystalline slag. No locality.

They are labelled A., C., D., F., and appear to belong to the same group as No. **3065.**

3068. Grey blast-furnace slag with a banded glassy border.

This border surrounds a hollow cavity, and shows a blue sheen when seen in certain lights.

3069. Crystalline blast-furnace slag, locality unknown.

This has a free irregular surface and has crystallised in an open space, the crystals are double pyramids of the oblique system with dull brown faces.

3070. Blast-furnace slag from Espedal, Norway.

Communicated by D. Forbes. A heavy dark mass in a sheet ¾-in. thick, showing on one side a number of flat metallic looking crystalline flakes.

3071. Iron-slag from the Manganja Hills, Africa.

Communicated by Sir John Kirk, 1862. They are small pieces of heavy black scoriaceous slag. They are produced in the process of extracting iron directly from the ore as described in Percy's Metallurgy, Iron and Steel, p. 275.

ANCIENT SLAGS.

3072. Old slag from a blast-furnace at Julsrudalen, Norway.

Communicated by D. Forbes. Probably between 150 and 200 years old. It is a grey within, and of a completely crystalline character, the individuals not being separable.

3073. Slag from old Norwegian bloomeries.

Communicated by D. Forbes. Probably over 200 years old. It is produced in the smelting of bog iron ore in pits by means of charcoal for the extraction of iron by the direct method, which was formerly alone in vogue, the furnaces being called bloomeries. *See* Percy's Metallurgy, Iron and Steel, p. 320. This is a black compact heavy mass like a basalt, which must still contain a large per-centage of iron.

3074. Old Roman slag from Uckfield, Sussex.

Communicated by A. Nesbit. These slags were found in great abundance in a certain spot near Uckfield where iron was formerly made. They were mostly removed for roadstone. Associated with these were found coins of Vespasian and others, pieces of Samian ware, and fragments of bronze fibulæ. Some of the pieces contained fragments of charcoal. These are black heavy crystalline slags resembling basalt, still retaining much iron. They are made from the nodules of clay ironstone which occur abundantly in the Weald clay.

3075. Piece of ancient blast-furnace slag from Ashdown Forest, Sussex.

Communicated by H. Bauerman from Mr. Larking's Collection. A green opaque glass, for the most part weathered dull.

3076. Mediæval blast-furnace slags from near Uckfield, Sussex.

These are formed on the same spot as No. **3074,** and have been obtained from the same source, but they differ essentially in character, being made of dark glass, with lighter lines of flow, and indicating a much more complete abstraction of the iron. Communicated by A. Nesbit.

3077. Doubtful slags from Mount Sinai.

Communicated by Francis Galton. They are derived from extremely ancient Sinaitic mines, which, if these are truly slags, were worked for iron. The small fragments are black, compact, and weathered on the surface, with earthy-looking brownish patches here and there. Dr. Percy calls them "black slag, not unlike iron slag." *See* his Metallurgy, Iron and Steel, p. 874.

3078. Old furnace slag, locality unknown, containing fragments of charcoal, with rounded pieces of unmelted micaceous iron ore, the bulk being a light scoriaceous glass.

MISCELLANEOUS PRODUCTS IN THE SMELTING OF IRON ORE IN BLAST-FURNACES.

3079. Black blast-furnace cinder drawn out into threads at the Dowlais Iron Works, South Wales.

The black glass is blown out by the blast, which rapidly cools it.

3080. Furnace-glass and wool produced at Cwm Cefn Blast-furnace.

Communicated by J. James, 1855. The glass is in fine sheets, and the "wool" in fine hair-like threads of the same greenish colour. It is a result of the slag coming in contact with the blast of the furnace.

3081. "Furnace-wool" produced when an iron smelting furnace was working badly, no water being present in the twyers.

Communicated by Mr. Roper. It has with it numerous round blebs of black glass.

3082. Hair-like slag, or "furnace-wool," produced at Dowlais Iron Works.

It was blown out, through the stopping, which was defective, round the back twyer of a blast furnace. Collected by Dr. Percy, 1870. It is interspersed with round dark blebs of glass.

3083. Slag-wool from the cupola at the London and North-western Company's Works at Crewe.

Communicated by Mr. Webb, 1881.

3084. "Furnace-wool," or "silicate cotton," from a blast-furnace at Elswick, Newcastle-on-Tyne.

Produced by the regurgitation of the blast. It is of a pure white colour, and has very few light transparent blebs.

3085. Hair-like form of slag from iron furnace at Königshütte, Upper Silesia.

Bought of A. Krantz.

3086. Three manufactured specimens of furnace-wool, which is now put to economic uses.

The most inferior is like those above, with an irregular fibre and numerous glassy blebs. The second is in asbestos-like shreds, consisting of bundles of fibres, and is tinged with brown. The third has the fibres long, uniform, and clear white, like the finest curled silk.

3087. Slag in small round pellets blown out of a small hole in the twyer side of one of the blast-furnaces at the Ormesby Iron Works, Middlesborough-on-Tees.

Communicated by F. H. Marshall, 1877. Each pellet is hollow, and the material of which the case is made is finely porous. Some are dark, but most are nearly white.

3088. Comminuted blast furnace slag, produced artificially to serve as a manure, at the Ebbw Vale Iron Works.

Communicated by G. Parry, 1863, who has patented the process, No. 476 of 1864. In the specification he states that it is produced by applying below the gutter along which the slag runs from the furnace jets of steam, obtained from the blast engine boilers, with a pressure of 17 lbs. to the square inch. The jets are made to resemble the bat's-wing burners for gas, so as to take the form of a thin sheet, striking on the descending stream of fluid slag; by this means it is drawn out into coarse wool, the absence of blebs being secured by an adjustment of the jet. It is afterwards powdered for use. The powdered slag is recommended for use in the manufacture of bricks, artificial stone or cement, and also as a mineral manure, on account of the soluble alkaline silicates it contains.

3089. Crystalline graphite from a blast-furnace at Elswick.

Communicated by A. Noble, 1868. It consists of brilliant micaceous plates of large size, which have formed on the surface of a loose mass of sand, probably the casting sand into which the pig iron runs.

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3090. Artificial graphite from iron furnaces, locality unknown.

These pieces contain fragments of slag, and are mixed with metallic iron.

3091. Graphite from the iron works of Sir William Armstrong.

A solid compact mass of irregularly arranged micaceous graphite, which surrounds numerous isolated pieces of metallic iron interspersed throughout the mass.

3092. Artificial graphite from Mr. Blackwell's Iron Works, Staffordshire.

Communicated by Mr. Blackwell, 1845. The mass of this is a grey grit (perhaps the "bear"), coated with large micaceous flakes.

3093. A mass of solid porous slag, with a growth of large graphitic crystals on one side, locality unknown.

3094. Graphite from the iron furnaces of Dowlais, South Wales.

Communicated by Mr. Child, 1862.

3095. Graphite from the iron furnaces of Dowlais, treated for the elimination of silicon.

It has been digested in hydrochloric acid, and heated in molten potash, and treated with hydrofluoric acid. It appeared to contain silicon, because when thus heated in molten potash it gave off an inflammable gas. *See* Percy's Metallurgy, Iron and Steel, p. 511.

3096. Graphite from a South Staffordshire iron furnace.

Communicated by T. Dawes, Bromford. Associated with loosely aggregated sand.

3097. Largely crystallised graphite from a blast-furnace at Barrow-in-Furness.

Communicated by J. T. Smith. The crystalline form may be clearly seen on these, some presenting the faces of scalenohedra, or pyramids, others show a low rhombohedron.

3098. Largely crystalline graphite from the Elswick Furnaces, Newcastle-on-Tyne.

Communicated by E. S. Noble, 1867. Shows no measurable surfaces.

3099. Crystalline graphite occurring as a vein in a piece of pig iron.

The large plates are transverse to the walls of the vein. From Chapell Hall's Furnace, South Staffordshire. The furnace was making No. 1, or hot iron, from blackband ironstone. The molten metal ran over the dam along with the cinder, so that it had two or three inches of cinder over it and one or two inches under it, and it lay undisturbed for about five or six hours.

3100. Graphite in large soft aggregated flakes, from a furnace at Arnaville, Val d'Aosta.

Communicated by H. Bauerman, 1871. The ore smelted was magnetite, and the fuel was charcoal.

3101. Loose graphite flakes or "kish," from the Clarence Iron Works, near Middlesborough-on-Tees.

3102. Samples of kish in its winnowed and in its crude state.

The latter contains foreign fragments which get mixed up with it, but which may be separated by winnowing.

3103. Brown material accompanying kish in the cavities of pig-iron.

On running out the pigs of a Middlesborough iron furnace in September 1863, the moulds were not filled up, but the iron formed cavities at the top and sides which were found filled with kish and this material. On analysis it yields :—

Carbon - - - -	23·6
Silica - - - - -	49·0
Ferrous oxide - - - -	16·2
Manganous oxide - - -	11·7
	100·5

It is thus a mixture of graphite with a ferro-magnesian silicate. Communicated by J. Lowthian Bell.

3104. Coating of oxide of iron from hot-blast pipes.

Obtained at the Russell Hall's Furnace, Dudley, 1851. The pieces are about five-sixteenths of an inch thick, and contain several concentric layers which are grey within, but red along the surface of junction.

3105. Slag which has spontaneously disintegrated. From the blast furnaces of Workington, Cumberland.

The slag, previous to its spontaneous disintegration, was grey and cellular. The powder when breathed upon gives an odour of sulphuretted hydrogen. It occurred in a furnace in which a mixture of "hard" and "soft" red hæmatite was smelted with the production of grey iron (No. **3195**). It is thought to be due to an excess of lime in the flux. *See* Percy's Metallurgy, Iron and Steel, p. 506. Communicated by W. W. Smyth.

3106. Silicate of lime in powder, produced in a blast furnace.

3107. Fume from the Stanhope Iron Furnace.

A rough brown powder.

3108. Sal ammoniac obtained from the gases of a blast furnace at Ebbw Vale.

Communicated by G. Parry, 1859. The consumption of raw coal instead of coke in smelting involves the elimination of the ammoniacal gases which are produced in the heating of coal. This gas has been dissolved in water and the solution evaporated. *See* Percy's Metallurgy, Iron and Steel, p. 475.

3109. Specimens of old "bears" or pieces of the floor of old blast furnaces, on which the molten iron has for a long time rested.

3110. Bear from old blast furnace, being an incrustation on the surface of a wrought-iron bar, gradually formed during the use of the furnace.

3111. Powdery deposit formed on the water-tymp in the blast-furnace of the Blaina Iron Works, South Wales.

3112. "Old horse" or part of the bottom of an iron blast furnace at Beaufort Iron Works, which was blown out in 1862.

It consists in the centre of a broad layer of white iron, which shows a rough columnar structure, the two sets of columns meeting in a middle line. This band is bounded by mixed material with cyano-nitride of titanium, and metallic particles and patches.

3113. Portion of a bear much impregnated with cyano-nitride of titanium, and having also metallic portions with a golden-yellow coat.

Locality unknown, but perhaps the Beaufort Iron Works.

3114. Graphitic products from the "dead horse" of a blown-out iron furnace in Yorkshire.

Communicated by T. E. Thorpe. The "dead horse" is the mass of metal, &c. which collects at the base of the furnace, and which has to be blasted out when the furnace is blown out for repairs. This substance has been kept continuously for 10 years at a temperature very near the melting point of cast iron. These products were obtained from a part of the horse just below the hearth of the furnace. Analysed by G. Johnstone. The specimen A. has large crystalline surfaces, forming part of a rhombohedron. It is hard and with a graphite-like lustre, and has a specific gravity of 5·485. It is composed of—

Iron - - - - -	87·00
Silicon - - - -	1·14
Carbon (combined) - - -	2·24
Graphite - - - -	8·30
Phosphorus - - - -	0·24
Sulphur - - - -	0·19
Manganese - - - -	0·96
	100·07

It is therefore a complex substance and may be separated by pounding in a steel mortar, one portion of which becomes readily a fine powder, and another assumes the form of malleable scales, the former being dark in colour and the latter light and more lustrous. The two parts have the following composition:—

	Scaly portion.	Powdery portion.
Iron	95·60	82·66
Silicon	1·56	0·93
Carbon (combined)	0·94	2·89
Graphite	1·62	11·64
Phosphorus	0·18	0·27
Sulphur	0·21	0·18
Manganese	trace	1·44
	100·11	100·01

The second sample has much smaller crystalline faces, but is also in rhombohedra, or scales. Its specific gravity is 4·892, and it is equally hard. It is composed of—

Iron	76·62
Graphite	19·62
Carbon (combined)	0·92
Silicon	1·99
Phosphorus	0·55
Sulphur	0·27
Manganese	0·14
	100·11

It is likewise separable into a powdery and scaly portion, which have the following composition:—

	Scaly portion.	Powdery portion.
Iron	94·48	65·59
Graphite	3·52	29·58
Carbon (combined)	0·10	1·43
Sulphur	0·10	0·39
Silicon	1·54	2·27
Phosphorus	0·36	0·64
Manganese	—	0·24
	100·10	100·14

3115. White fibrous silica deposited on the surface of the bear of a blast-furnace. From a Scotch blast-furnace before 1873.

Analysed by J. Butterfield, and found to contain—

Silica	97·50
Manganous oxide	1·08
Ferrous oxide	1·74
	100·32

The smaller specimen shows, at the same time, the copper coloured crystals of cyano-nitride of titanium. It is supposed to be the product of the oxidation of the silicon, which is separated with the iron at an earlier stage. *See* Percy's Metallurgy, Iron and Steel, p. 508.

3116. Fibrous silica from the hearth of Wingerworth Blast Furnace, near Chesterfield.

Communicated by T. Blair. Composed of superimposed globular masses, of nearly one inch in diameter, of a white colour and silky lustre. With this is a specimen of the sandstone used for the hearth on which the fibrous silica was formed.

3117. Fibrous silica from the hearth of the Wingerworth Blast Furnace, near Chesterfield.

Communicated by J. Blair. This shows the globular fibrous silica adhering to the solid bear which has been consolidated. It has been analysed and yields 99·10 per cent. of silica, 0·80 per cent. of alumina and mere traces of iron and lime. It occurred as a layer between the bed and the iron. The bed was composed of red Mansfield sand, which is altered throughout into a white quartzite, the iron only contained 2·00 per cent. of silicon. It is noticed in the Transactions of Iron and Steel Institute, Vol. II., 1884, p. 575.

3118. A white substance which peals off the surface of iron castings.

Communicated by E. Riley. It occurs when the castings are bad in quality, it is loosely attached and can easily be separated. It probably consists chiefly of silica.

3119. Spherical coat of radiately fibrous silica separated from off the surface of a globule of cast iron.

Communicated by J. Turner, 1886. It was produced as follows: Goran silicon pig with 10 per cent. of silicon was mixed with South Staffordshire white cinder pig to produce a soft casting. Melting was performed in a Stourbridge clay crucible, and after pouring the pot was replaced in the fire and the whole allowed to cool. These globules of iron were afterwards found within, some with the siliceous coat and some without: the coating is quite soft. Its formation is believed to be due to the presence of sulphur and silicon together in molten iron in an oxidising atmosphere.

3120. Reduced nodule of clay ironstone from the breast of an iron furnace.

Communicated by J. Turner. Blaina Iron Works. The nodule had been fixed about 10 feet above the ground and was obtained when the furnace was being repaired. It is now entirely metallic, but hollow in the centre and porous.

3121. Old bear from the Russell Hall's Blast Furnaces, Dudley, containing crystals of cyano-nitride of titanium.

In the smallest of these there is also some white crystalline material.

3122. Cyano-nitride of titanium, contained in old bear, and in pieces of cast iron associated. From Cwm-avon, Taibach.

3123. Cyano-nitride of titanium from a blast furnace at Pontypool, South Wales.

The copper coloured mineral is here distributed in veins. The furnace had been in blast for 2½ years.

3124. Cyano-nitride of titanium from the blast furnaces of Bromford, near Birmingham.

Communicated by Mr. Dawes. This is a very porous slag forming part of the bear, in the crevices of which the copper coloured crystals are formed. It was only observed in this furnace when Cumberland hæmatite ores had been smelted.

3125. Bear of iron furnace at Bromford, containing titanium.

Communicated by Mr. Dawes. The crystals are here so finely disseminated, that the substance can only be recognised by the colour.

3126. Bear, containing titanium, from the Russell Hall's blast-furnace.

Communicated by S. H. Blackwell. A porous crystalline slag, with an occasional tinge of brown, but the visible crystals are very minute.

3127. Cyano-nitride of titanium, from Herbert's Park Iron Works.

Some of these show perfectly the crystallisation in cubes. For the character of these crystals and their composition, *see* Percy's Metallurgy, Iron and Steel, p. 510.

3128. Cyano-nitride of titanium, from the ironworks at Fourchambault, Nièvre.

Communicated by Mr. Rees.

3129. Powdered and lævigated titaniferous bear, in which the crystals of cyano-nitride are separate and loose.

Communicated by Dr. Noad.

3130. Piece of a "bear" from an iron furnace in Scotland.

It contains in addition to the small cubes of cyano-nitride of titanium some green slag in cavities, and also some white, hollow, rhombohedral (?) crystals.

3131. Scoriaceous "bear," locality unknown.

This contains abundant cubes of cyano-nitride of titanium, which are slightly hopper shaped, also some brilliant black octahedral (?) crystals and some greenish yellow opaque glass.

3132. Scoriaceous bear with iridescent crystals of cyano-nitride of titanium.

This is very similar to the last, and is probably from the same locality.

3133. Cyano-nitride of titanium in the "bear" of the Russell Hall's Furnaces, Dudley.

Communicated by S. H. Blackwell. It is in large cubical crystals.

3134. Piece of "bear" consisting mostly of pig-iron, coated with some cyano-nitride of titanium, and showing here and there some isolated white prismatic crystals of small size. Locality unknown.

3135. Mixture of iron and charcoal from an old bear, containing bands of crystalline cyano-nitride of titanium.

This shows the production of this compound under different circumstances to the others, viz., with the use of charcoal.

3136. Large mass of "bear," mostly composed of pig-iron, much impregnated with cyano-nitride of titanium.

The cubical crystals are here imperfect, and the developed portions are built up into various forms, among them some perfect octahedra, as mentioned by Dr. Percy in his Metallurgy, Iron and Steel, p. 511, as occurring in a South Wales specimen, which may be this one.

3137. Mass of cyano-nitride of titanium imbedded in pig-iron.

Very few isolated cubes are here seen, but the mass is built of octahedra, strongly striated parallel to the base. In bulk it much resembles copper, but is immediately distinguished by its greater hardness.

3138. Mass of pig-iron with cyano-nitride crystals on the surface.

In this the octahedra are isolated, and no larger than the ordinary cubic crystals. They are deeply striated, or even stepped parallel to the base.

3139. Pig-iron mixed with unconsumed coal and infiltrated with narrow veins of cyano-nitride of titanium, without any clear signs of crystallisation.

3140. Bear, with cyano-nitride of titanium, of a lighter tint than usual.

3141. Scoriaceous bear, consisting of pig-iron, covered by dark crystals.

These crystals resemble in every respect the cubes of cyano-nitride of titanium, but they are black instead of red. Some even show the coppery tint. They are doubtless only altered superficially.

3142. Scoriaceous bear, with abundance of small dull crystals.

These are black in colour and mostly octahedral. They appear to have a hopper-like growth, and they are associated with coppered coloured crystals.

3143. Bear, with two distinct sets of crystals.

The most abundant are octahedral. They are often coated over on the surface so as to be dull, but within they are brilliant black. The cubes of the cyano-nitride of titanium are quite distinct. Compare Nos. **3131** and **3142.** The specimens above, without localities assigned, were obtained, either from the Russell Hall's Furnaces, Dudley; the Hæmatite Iron Furnaces, Workington, Cumberland, communicated by C. Litt ; or from Catamarca, communicated by L. Quevedo ; but the specimens are mixed.

3144. Metallic zinc in the crevices of a blast furnace.

This escaped from the crevices in brickwork just over the twyer of a blast-furnace at the Ebbw Vale Iron Works. The ore being smelted was spathic carbonate from Perranlode, near Perranzabuloe, Cornwall, and the ore as traced in depth soon changes to blende. This specimen illustrates the possibility of zinc vapour being accidentally condensed without any special arrangements for the purpose, as may have been the case in the discovery of brass. *See* Percy's Metallurgy, 1861, p. 519. Communicated by G. Parry.

3145. Blast-furnace calamine, or cadmia. From the Wear Furnace, Washington, Durham.

A deposit of zinc oxide which forms round the throat of the furnace when zinciferous iron ores are smelted. It consists of innumerable concentric layers of dark grey zinc oxide, with a green surface coating. Communicated by W. Meredith.

3146. Masses of furnace calamine removed from a few feet below the filling plates at the Russell Hall's Iron Furnace, Dudley.

Communicated by S. H. Blackwell. The pieces are compact, some black and some green, but are immediately recognised by their fine lamination.

3147. Stalactitic form of zinc oxide, from the neck of a gas culvert at the top of a furnace making spiegeleisen.

Either from Brown & Co.'s Works, Sheffield, or from Ebbw Vale. Dirty yellow green in colour on the surface, but darker within.

3148. Crystallised oxide of zinc from a "scaffold" in one of the Landore iron-smelting blast-furnaces.

Communicated by A. Willis, 1875. The crystals of zinc oxide are in the form of incrustations on pieces of cinder. They are a yellowish-green, and some grey or brown. Some of the incrustation is globular, apparently coating the larger crystals, which are small stout hexagonal prisms, modified by a pyramid and basal plane.

3149. Crystalline incrustation of oxide of zinc in the cavities of brickwork in No. 1 Furnace, Ebbw Vale.

Communicated by G. Parry. The crystals are very minute, and are arranged in botryoidal clusters. They are narrow hexagonal prisms, dark green, or discoloured so as to be dark grey.

3150. Yellow crystals accompanying the oxide of zinc in the above named cavities at Ebbw Vale.

These are perfect sulphur-yellow transparent octahedra. As some of them are perfectly colourless, the yellow colour of the others must be due to staining, and they are probably sal-ammoniac. They smell strongly of sulphur when heated, to the presence of which the colour is doubtless due.

3151. Crystallised oxide of zinc from a "scaffold" in a furnace in which Porman ores were being smelted.

Communicated by H. E. Hackney. The crystals are on the surface of an incrustation, and are green and needle-like, consisting of hexagonal prisms truncated by a basal plane.

3152. Incrustations of crystals of zinc oxide on the lining bricks of the hearth in one of the blast-furnaces of the Tredegar Iron Works, South Wales.

Communicated by R. Cowper. The crystals have been analysed, and yielded 100·13 per cent. of zinc oxide. Four distinct forms of crystals have been recognised. The form is an hexagonal prism, terminated by a basal plane, by a pyramid of the same order, or by both, and the last combined with a second hexagonal prism.

3153. Incrustation of zinc oxide from the Halsbrücke Furnace, Germany.

On a burnt white brick. Some of the crystals are hexagonal prisms, of a greenish-yellow colour.

3154. Zinc oxide from the iron furnaces of the Absacher Works, at Kirn on the Rhine.

Communicated by Plattner, of Freiberg. On pieces of unsmelted clay ironstone. In botryoidal clusters of small crystals, like No. **3149.**

3155. Furnace product in the form of Diopside, from Coopers Furnace, Philipsburg, New Jersey.

Communicated by G. J. Brush. They are white, transparent, interlacing, prismatic crystals, found in the solid mass resting on the hearth when the furnace was cooled, just above the twyers or 3½ ft. from the bottom. They occurred nowhere else. The prisms have been determined to be rhombic, whose acute angle is about 87°, and are truncated by a second prism. An analysis by Peter Collier gives—

Silica - - - -	49·91
Alumina - - - -	5·01
Lime - - - - -	23·13
Magnesia - - - -	17·33
Ferrous oxide - - -	0·40
Potash - - - -	1·42
Soda - - - - -	2·16
Calcium - - - -	0·31
Sulphur - - - -	0·25
	99·92

From whence it is concluded that the mineral is a Diopside. *See* Paper by G. J. Brush, Am. Journ. of Science, March 1865.

3156. Garnet produced in the base of an iron furnace at Monkland, Scotland.

Examined by Professor W. H. Miller, who has published a description of it in the Phil. Mag. 1858. There are several dark red, garnet-like crystals in a drusy cavity on the surface of a stony bear. One of them is a combination of a trapezohedron with a rhombic dodecahedron; a form very characteristic of natural garnets. This, in 1871, was the only instance of a garnet occurring as a furnace product in this country. *See* Percy's Metallurgy, Iron and Steel, p. 509.

3157. Argentiferous lead from a blast-furnace in which Porman ore was smelted.

Communicated by H. E. Hackney. It has run down in little irregular drops.

3158. Deposit of oxide of lead from the gutters of the iron furnaces of the Absacher Works, at Kirn on the Rhine.

Communicated by Plattner. Fragments of a bright red amorphous mass.

3159. Deposit of chloride of ammonium, obtained from crevices in the brickwork of a blast-furnace at Ebbw Vale.

Communicated by W. Adams. This consists of deeply coloured transparent octohedra. Compare Nos. **3150** and **3108.**

3160. Brown and black minute crystals from a cavity in the brickwork of No. 1 Furnace at the Ebbw Vale Iron Works.

Communicated by G. Parry. Too minute to determine.

3161. Blebs of lead oozing out from the surface of the bricks in No. 1 Furnace at Ebbw Vale Iron Works.

Communicated by G. Parry.

3162. Brass-yellow metallic-looking film from the surface of a "horse" in a furnace at the Landore Iron Works, South Wales.

Communicated by H. E. Head, 1881. The furnace was working with Bilbao and other Spanish ores, with a little from Llantrissaint, and had been in blast about a year and a half.

3163. Mass that was originally clay, and which lay immediately below the "bear" of an iron furnace at the Port Clarence Works, Middlesborough.

It is now an indurated shale, with a tendency to split into flakes, but is not in the least crystalline.

3164. Mass of sandstone which has been used in a hearth of a blast-furnace at Russell Hall's Iron Works, South Staffordshire.

Communicated by S. H. Blackwell. One specimen is in its original state, the other has been for some years exposed to continuous heat. It has thereby been changed into a quartzite, with disseminated particles of iron. Although the sandstone is a tolerably coarse grained one, the metamorphosed rock is very compact and not visibly crystalline.

3165. Portions of the hearth of a blast-furnace at the Monkland Iron Works, Calder Bank, Glasgow.

These were from 18 in. to 3 ft. below the mouth of the twyers. The furnace had been in blast for 10 years, and was all built of brick. Some portions of these may be garnetiferous.

3166. Miscellaneous pieces of "bear" of locality unknown, probably from South Wales.

They may contain a variety of products. The specimen marked **1611** contains crystals which appear to be octahedra like those of magnetite. In several are to be seen dark rounded masses, the colour of which is like that of fused silicon, some enclosing crystals of cyano-nitride of titanium.

3167. Bear from the Russell Hall's Iron Furnace, South Staffordshire, showing a white incrustation.

Some of the minute crystals are tinged with yellow. They are too small to make out, but they resemble the zinc oxide.

3168. Portion of a "scaffold" in No. 8 Furnace at the Monkland Iron Works, Calder Bank, Glasgow.

Showing the state of the "scaffold" resting on the boshes thrown out in an explosion which threw out about 200 tons at the tymp. It is scoriaceous, and largely metallic.

3169. Conglomeration of coal dust and cinder taken out of the Kilgetty blast-Furnace, Saundersfoot, South Wales.

A compact coke-like mass, with numerous particles of green slag.

3170. Crystals deposited on a hard surface in an ironworks in South Staffordshire, 1868.

Communicated by W. Farnworth. They are skeleton octahedra like magnetite. Sometimes complete, often the edge is shorter on one side than on the other, so that the boundary is open.

VARIETIES OF PIG-IRON OBTAINED BY SMELTING BRITISH ORES.

3171. Pig-iron obtained by smelting the Cumberland hæmatite by the West Cumberland Hæmitite Co. No. 1.

Uniformly blue-grey with a rather coarse crystalline fracture. On analysis it yields—

Graphite - - - -	3·142
Silicon - - - -	2·900
Sulphur - - - -	0·023

Phosphorus - - - -	0·023
Manganese - - - -	0·075
Iron - - - - -	93·837
	100·000

3172. Pig-iron obtained by smelting another mass of ore at the same furnaces. No. 2.

Also uniformly blue-grey, with a finer grained fracture. On analysis it yields—

Graphite - - - -	2·993
Silicon - - - -	3·080
Sulphur - - - -	0·021
Phosphorus - - - -	0·021
Manganese - - - -	0·079
Iron - - - - -	93·806
	100·000

3173. Grey pig-iron, No. 1. Produced at the Ystalyfera Iron Furnaces, South Wales.

Finer grained at the bottom than at the top.

3174. Grey pig-iron, No. 2. Produced at the Ystalyfera Iron Furnaces, South Wales.

The grain is coarsest inside.

3175. Grey pig-iron, No. 3. Produced at the Ystalyfera Iron Furnaces, South Wales.

The grain is very like that of No. 2. The ores used at these furnaces were the argillaceous ironstones of the South Wales Coal Measures with a proportion of hæmatite from Ulverstone.

3176. Bright iron. Produced at the Ystalyfera Iron Furnaces, South Wales.

This is closer grained than the others.

3177. Mottled iron. Produced at the Ystalyfera Iron Furnaces, South Wales.

A cross fragment of a pig finely spotted grey and white, and with a very fine grain.

3178. White iron. Produced at the Ystalyfera Iron Furnaces, South Wales.

Fine grained and compact, with crystals feebly shown, radiating from the surface to meet in the centre.

3179. Grey pig-iron. Produced at the Newland Furnaces, Ulverstone, Lancashire, 1856.

Communicated by Mr. Roper. A small pig of varying grain, said to be kishy. The slag from this smelting is No. **2989.**

3180. Close grey pig-iron. Produced at the Newland Furnace, Ulverstone, 1856.

Communicated by Mr. Roper. Irregular in the grain. The slag from this smelting is No. **2991.**

3181. "Mottley" pig-iron. Produced at the Newland Furnace, Ulverstone.

Communicated by Mr. Roper, 1856. A coarse pig, with casting material imbedded, mostly composed of white iron with a radiate crystallisation from the surface, the materials in the centre being spotted with grey iron.

3182. White iron. Produced at the Newland Furnace, Ulverstone.

Communicated by Mr. Roper, 1856. A small pig entirely crystalline, the crystals radiating inwards from the surface.

3183. White pig-iron. Produced at the Newland Furnace, Ulverstone.

Communicated by Mr. Roper. This is white iron crystallising from the surface, with hollow air-blown cavities. This iron is unsaleable and is the result of a long continuance of bad working, so that the ore comes down to the twyers in a raw and unaltered state. The slag produced in this smelting is No. **2995.**

3184. Grey pig-iron. Produced at the Gartsherrie Furnaces.

Communicated by Mr. Davis. A very fine grained iron.

3185. " Langloan " pig-iron.

Communicated by Mr. Davis. A rather coarse grained crystalline iron.

3186. Pig of cast iron, showing white iron round the edges and grey iron in the centre. Locality unknown.

3187. Grey pig-iron from Dallmillington.

Communicated by Mr. Davis. It is a shallow pig, and has an excessively fine grain, slightly mottled with white iron.

3188. Mottled pig-iron, almost entirely white with only a few spots of grey iron near the centre. Locality unknown.

3189. White iron showing radiating structure.

The surface is nearly an accurate circle whose centre is at the spot whence the crystalline fibres diverge with the greatest regularity.

3190. Vesicular pig-iron. Produced at Russell Hall's Furnaces, Dudley.

The iron is uniformly interspersed with hollow round vesicles, occupying about half the bulk of the pig.

3191. Pig-iron produced at the Summit Foundry, West Bromwich.

Communicated by R. Farley, 1881. This class of pig is used for casting chilled rolls for rolling sheets of iron.

3192. Mixture of iron. Produced at the Summit Foundry, West Bromwich.

Communicated by R. Farley. A special mixture used for rolls that are required for rolling steel plates. It is of great tensile strength, and will stand expansion and contraction.

3193. Iron called "Hange Pig."

Two samples. Moderately fine grained.

3194. Mottled iron. Produced at Ystalyfera Iron Furnaces, North Wales.

A shallow pig the border of which is radiately crsytallised white iron, the interior for more than half the bulk is granular grey iron.

3195. Pig-iron in two varieties. Produced in the furnaces of the West Cumberland Hæmatite Co.

The first variety is of a lighter colour than the second. They are made from a mixture of the hard and soft hæmatite with Marlyhill coke, using the hot blast.

3196. Common white forge pig-iron. From the Dowlais Furnaces, South Wales, 1871.

A broad shallow pig, of a light tint, but showing no crystallisation, and perfectly and finely granular.

3197. Small piece of white pig-iron. From the Cyfartha Iron Works, South Wales, 1859.

One side shows a pitted surface, with round depressions, like the prints of rain drops, on the other are some minute conical protuberances like icicles.

3198. Ballast pig-iron from Portsmouth Dockyard.

A broad mass of mottled cast iron with a coarser mottling on one side than on the other.

3199. Two samples of pig-iron made at Whitehaven Furnaces, from the Cumberland hæmatite, one by the aid of fluxes and the other without.

Communicated by W. Randleson, 1851. Sample No. 1 has been smelted without the fluxes. It is found to be irregular in structure, very compact externally, and fibrous and loose internally with a red tinge probably due to unreduced ore. It is also found to be weaker. Sample No. 2 is from the same ore treated with usual limestone flux and is more regular in the grain.

3200. Pig-iron said to be rich in silicon.

Used in producing gun-steel by the open hearth process at the Arsenal, Woolwich. Procured in 1884. Exteriorly it is a white iron, within there are drusy cavities lined with brilliant black crystals, of undetermined nature.

3201. Pig-iron from the Whitehaven Hæmatite Iron Company, Cleator Moor.

Analysed by C. Tookey, gives--

Carbon	2·99
Silicon	2·60
Phosphorus	0·05
Sulphur	0·16
Manganese	0·56
Iron	93·64
	100·00

3202. Pig-iron, No. 1. Analysed for Messrs. Cammel, 1874.

It contains 5·71 per cent of silicon, 3·46 per cent. of carbon (combined or uncombined), and 0·43 per cent. of titanium.

3203. Pig-iron, No. 2. Analysed for Messrs. Cammel, 1874.

It contains 5·81 per cent. of silicon, and 3·46 per cent. of carbon.

3204. Pig-iron, No. 3. Analysed for Messrs. Cammel, 1874.

It contains 5·375 per cent. of silicon, 36·44 per cent. of carbon, and 0·22 per cent. of titanium.

3205. Pig-iron, No. 4. Analysed for Messrs. Cammel, 1874.

It contains 5·35 per cent. of silicon and 3·57 per cent. of carbon. All these four pigs are of grey iron with a uniform rather fine grain.

3206. Pig-iron made from hard hæmatite ores and containing 2·2 per cent. of silicon. From the Whitehaven Hæmatite Company's Furnaces.

3207. Pig-iron made from soft hæmatite ores, and containing 1·87 per cent. of silicon. From the Whitehaven Hæmatite Company's Furnaces.

3208. Pig-iron made from a mixture of hard and soft hæmatite ores and containing 2·64 per cent. of silicon. From the Whitehaven Hæmatite Company's Furnaces.

Of these irons all are grey, the first two are fine grained, the last is coarser.

3209. Pig-iron containing 7·5 per cent. of silicon. From Dowlais Furnaces, South Wales.

Communicated by E. Riley, 1859. It was made many years previously from a very weak black band of the Coal Measures. It is very white in tint and said to be very fluid when melted. The amount of silicon confirmed by W. Weston.

3210. Pig-iron rich in phosphorus.

Communicated by F. Abel, 1859. The portion which remained longest melted, and consequently which was the last to solidify, contained the most phosphorus. The larger piece shows an external coating of white iron and the inner part is grey. The small piece belongs entirely to the outer coat of white iron.

3211. Filings of pig-iron. Analysed by W. Weston. Locality not stated.

It contains—

Iron - - - - -	90·87
Graphite - - - -	2·06
Silicon - - - -	6·02
Sulphur - - - -	0·23
Phosphorus - - - -	0·36
Manganese - - - -	0·32
	99·86

3212. Iron said to contain 19 per cent. of silicon.

It is acted on with great difficulty by hydrochloric acid. Communicated by W. Flight, received from Lawrence Smith, United States, 1880.

3213. Illustration of the working of ilmenite as an ore.

Consisting of a mass of ilmenite, a fragment of a cast iron bar produced from it, which is fine in the grain and mottled in colour, and the slag which accompanies it, which is opaque, glassy, and tinted with blue. Communicated by E. Riley.

3214. Pig-iron remelted, said to contain phosphorus.

Two samples communicated by J. P. Marrian, Birmingham. Both show a copper-coloured tarnish, one is scoriaceous and has arborescent crystallisation, the other is still more copper-tinted.

3215. Sample of chilling iron, cast at the London Road Iron Foundry, Edinburgh.

Communicated by H. Louis, 1880. It is a mixture of several different kinds of pig-iron, and shows a remarkable change from grey to white iron, passing from one side of the ingot to the other. The white fibrous crystallisation dies out amidst the dark grey particles. The white iron is more compact on the exterior surface than the grey. On analysis before chilling the mixture yields—

Graphite - - - -	3·0
Carbon combined - - -	0·5
Silicon - - - -	1·0
Phosphorus - - - -	0·3
Sulphur - - - -	0·1

Manganese	0·5
Iron	94·6
	100·00

3216. "Llynvi" iron, recast from the pig. From ironworks near Bridgend, Glamorganshire.

The iron is chiefly smelted from the black band ironstone of the Coal Measures. It is very red short. Communicated by Mr. Crawshay.

3217. Specimens illustrating experiments on chill-casting of iron in Portsmouth Dockyard.

Communicated by W. Weston, 1868. The castings are from the mottled ballast iron, No. **3198.** Two of them were cast in sand, the one from the most mottled iron still showing some mottling in the centre; and two are cast in metal, in which the iron has a crystalline fracture radiating from the surface.

Foreign Pig-Irons.

3218. Light fluid iron, made from bog-iron ore.

It is cast in a small ingot, and is said to be very brittle and only to be used when mixed with grey iron. Obtained from A. Krantz.

3219. Crystalline white iron, smelted from Elba ore, by means of charcoal.

Communicated by Messrs. Hunt of the Brades, 1848.

3220. White rough iron. From the Grosteiner ore, smelted at Malapane, Upper Silesia.

A piece of a small ingot. Obtained from A. Krantz.

3221. Iron made from chrome iron ore in Upper Silesia.

A small porous fragment of a pouring. Obtained from A. Krantz. Examined by A. Dick, and found to contain no chromium.

3222. Iron from the Gleiwitz Furnace, Upper Silesia.

Obtained from A. Krantz. It has been for a whole year in a fluid condition. It is now coarsely crystalline.

3223. Pig-iron from Finspong, Ostgothland, Sweden.

Communicated by C. Eckman. Gothenburg, 1848. It is a turning out of a cylindrical mass, broken across to show the fracture. This is mottled white and grey; the white iron forming a network seen on the cut surface.

3224. A second example of pig-iron from Finspong.

In this there is more grey than white iron.

3225. A third example of mottled pig-iron from Finspong.

This shows extremely well the mottled appearance produced by the white iron forming a network in which the grey iron is enclosed. This iron is only used for ordnance purposes. It contains a notable proportion of sulphur; in fact, some ore containing pyrites is intentionally added to the charge in order to supply the iron with sulphur, which adds to its strength. *See* Percy's Metallurgy, Iron and Steel, p. 554. A similar structure has been intentionally produced by adding sulphide of iron to grey pig-iron. *See* Percy's loc. cit., p. 133.

3226. White iron from a Swedish furnace, showing a very coarse crystalline fracture.

3227. Swedish charcoal pig-iron from Bjornëborg.

Communicated by C. Sandberg. It is made from the Persberg ore, and has been cast into a flat iron dish. The portion which has cooled in contact with the bottom and side has produced white iron, which is in large crystals, separated by a sharp line from the granular grey iron of the upper surface.

3228. Swedish pig-iron, cast in an iron mould, and showing distinct separation of the grey and white iron.

Possibly from the same casting as the last.

3229. Pig-iron from the Finspong Iron Works, Nörkoping, Sweden.

Examined by W. J. Ward, and found to contain copper, 1·365 per cent.

3230. Pig-iron cast in chill, at the Finspong Iron Works, Nörkoping.

Analysis by Andreas Gull. It contains—

Iron	85·27
Manganese	6·08
Alumina	0·97
Lime	1·37
Magnesia	0·43
Silica	4·77
Carbon	1·04
Phosphorus	0·89
Sulphur	0·01
	100·83

This, therefore, notably differs from the previous ones in the almost total absence of sulphur. It has been re-cast; the sides and base are white, the centre is minutely mottled; but all is of very fine grain.

3231. Fragment of grey pig-iron brought from India, and said to be of very good quality.

It is dark and very finely granular.

3232. Pig-iron from Madras, called "grey."

It is part of an ingot, almost entirely composed of white iron, with a long crystalline fracture.

3233. Foundry pig-iron, No. 1. Produced at the Dunbar Iron Works, Pennsylvania.

It is smelted from ⅓ Lake Superior ores, and ⅔ "Native" ores, and cast in a large pig, with coarse fracture.

3234. Foundry pig-iron, No. 1. Produced at the Dunbar Iron Works, Pennsylvania.

It is smelted from ⅕ Lake Superior ores, ⅗ "Native" ores, and ⅕ mill cinder.

3235. Foundry pig-iron, No. 2. Produced at the Dunbar Iron Works, Pennsylvania.

It is smelted from ⅕ Canadian ore, ¼ mill cinder, and the rest of "Native" ore.

3236. Standard forge pig-iron. Produced at the Dunbar Iron Works, Pennsylvania.

It is smelted from ⅕ Lake Superior ores, ⅖ Canadian ore, and ⅖ "Native" ore. It is of finer grain than the foundry pig irons.

3237. No. 2 iron from the Iron Works of Newark, New Jersey.

A very finely crystalline white iron; the fibrous crystallisation not been visible in a fracture transverse to the length. This is originally derived from franklinite, an ore of zinc (*see* No. **1255**), which after extraction of the zinc (*see* No. **2930**) is treated for iron.

ANCIENT PIG-IRONS.

3238. Ancient pig-iron from the Forest of Dean.

This is the grey iron which was made in the Forest of Dean in the 16th century, probably very soon after the discovery of pig-iron had been made. Communicated by D. Mushet from Col. Yorke's collection. The next is the accompanying slag.

3239. Blast furnace slag from ancient iron smelting works of the 16th century in the Forest of Dean.

Associated with the pig-iron above. It is partly greenish-grey, and compact, and partly a purplish glass. From Col. Yorke's collection.

3240. Chips of cast iron belonging to the 14th or 15th century.

These small pieces were chipped from the interior of a bombard of the 14th or 15th century; found in the ditch of Bodiham Castle, and afterwards exhibited at Battle Abbey. Its bore was 15 inches, and it was strengthened externally by wrought-iron hoops. These pieces of cast iron prove the discovery of that material as distinguished from wrought iron, prior to the date named. Communicated by J. H. Lefroy.

SPIEGELEISEN.

3241. Spiegeleisen from Messrs. Bird & Co.

Very white and well crystallised with a dark tarnish. Analysed by W. J. Ward. It contains:—

Carbon	5·05
Silica	0·23
Phosphorus	0·04
Sulphur	0·01
Manganese	2·96
Iron by difference	91·71
	100·00

3242. Spiegeleisen from Rudolf, Wolff & Co.

With a very brown tarnish. It contains 7·25 per cent. of manganese.

3243. Spiegeleisen from Mr. Attwood. From Tow Law Works, Durham.

Examined by W. J. Ward. It contains 2·16 per cent. of manganese. Compare the analysis of a similar specimen by W. J. Ward in Percy's Metallurgy, Iron and Steel, p. 534.

3244. Spiegeleisen from Dowlais Iron Works, South Wales.

Analysed by W. J. Ward.

3245. Spiegeleisen, containing 12·7 per cent. of manganese.

Communicated by E. W. Harvey.

3246. Spiegeleisen manufactured from the residue of Franklinite at Shirley Works, New Jersey, U.S.A.

Communicated by J. Bauerman, 1866. *See* an analysis of a similar specimen in Percy's Metallurgy, Iron and Steel, p. 534.

3247. Spiegeleisen showing well marked crystalline forms.

Communicated by John Brown & Co., Atlas Iron Works, Sheffield. Some of the forms closely approach oblique rhombs.

3248. Spiegeleisen from an unknown locality.

3249. Mass of cast iron resembling spiegeleisen unintentionally produced at the Longton End Iron Works, Longton, Staffordshire.

The furnace was charged with one third of Froghall Hydrate ore, about one third of "Bassy and Red" Mines, and one third the lean ores of the neighbourhood, the fuel was the "ash" of the neighbourhood, with a small proportion of Durham coal. Communicated by J. Goddard and Sons.

3250. Another specimen of the same accidental spiegeleisen, showing flat thin crystalline plates.

3251. Spiegeleisen with a crystalline surface of thin iridescent laminæ which cross each other.

Communicated by the Bowling Iron Co., Bradford, Yorkshire. From a German brand of spiegeleisen—"au." On analysis the bulk was found to contain 0·32 per cent. of silicon, 0·023 per cent. of sulphur, 0·096 per cent. of phosphorus, and 10·71 to 10·78 per cent. of manganese.

3252. Spiegeleisen with large surface crystals of thin tabular form, which are coated over with some crystals of graphite which have separated out on cooling.

Communicated by Dr. L. Beck, Darmstadt.

3253. Spiegeleisen with very well defined cleavage surfaces. Locality unknown.

3254. Spiegeleisen made at Landore from Carthagena ores.

It contains about 10 or 12 per cent. of manganese, and 3 or 4 per cent. of silicon. Communicated by H. E. Hackney.

3255. Specimens of spiegeleisen in the form of large separate plate-like crystals.

3256. Oils obtained by the action of sulphuric acid on spiegeleisen.

The deep coloured oil is the crude oil, the rest have been separated by distillation, and came off respectively at the temperatures 200°–210° F., 210°–230°, 230°–250°, 250°–270°, and above 270° F. Experiments by C. Tookey.

SPECIAL CRYSTALLISATIONS OF IRON.

3257. Cast iron crystallised as an octahedron.

Communicated by G. Matthey, 1871. It has a rough surface, and is of complex origin.

3258. Cast iron artificially crystallised in octahedra.

From the Demidoff Iron Works, Siberia, 1880. The octahedra occur in a drusy cavity, and are mostly striped parallel to the sides by a succession of growths.

3259. Section of coke-pig, produced by hot blast at the Londonderry Furnaces, Nova Scotia, showing here and there, some octahedral crystals.

Communicated by H. Louis.

3260. Crystallised pig-iron, produced at the Russell Hall's Furnaces, Dudley.

Communicated by S. H. Blackwell before 1851. It is a surface formation of rectangular crystals occasionally arranged in an arborescent form.

3261. Arborescent crystals of cast iron, from the centre of a block cast for the fortifications of Todleben, 1880.

3262. Arborescent crystals of cast iron, from Staffordshire.

3263. Arborescent crystallisation in cast iron from the Clyde Iron Works.

Communicated by D. Mushet from Col. Yorke's collection, 1875. These crystals are so arranged as to form in many cases skeleton octahedra.

3264. Crystallised pig-iron, locality unknown.

This is not arborescent, but consists of numerous skeleton octahedra placed one on top of the other so as to form a tetragonal pyramid, which is terminated by the final octahedron.

3265. "Kishy" pig-iron with large crystals.

From the Newland Iron Furnaces, Ulverstone, Lancashire. Communicated by E. Roper. This is obviously not from a regular pig, but a portion of the iron which did not go into the moulds; it contains a piece of imbedded stone.

3266. Very largely crystalline cast iron. From the Elswick Works, 1868?

The surfaces are brilliant; they meet at acute angles, and have their faces obliquely striated, and there is nothing to show them to be isometric. The fragment is not from a pig, but from a flat cake, and it contains several pieces of imbedded stone.

3267. Very largely crystalline cast iron. From the Elswick Works, Newcastle-on-Tyne, 1867.

Communicated by E. S. Noble. This is also from a flat mass, the crystals on one side are immense. Their faces are striated by two sets of lines, making angles of 60° as though the system was hexagonal. The other side has the ordinary fine crystals of grey iron.

3268. Kishy iron produced at the Blaina Iron Works, Newport, Monmouthshire.

Communicated by J. F. Davis. The metal shows coarsely crystalline plates, or a graphitic appearance, and crossed by lines making angles of 60° with each other. It occurred when the burden was very light; and composed of Redmine calcined ironstone, a small portion of burnt cinders and very strong coal and coke, the furnace working with hot blast. The iron adheres firmly to a coating of slag.

3269. Pig of cast iron, showing a layer of larger crystals at some depth from the surface. Locality unknown.

3270. Crystalline iron from No. 1 Furnace, Chapel Hall, Staffordshire.

PIG-IRON PRODUCED UNDER SPECIAL CIRCUMSTANCES.

3271. Columnar iron forming part of the "bear" or "horse" of a blast furnace at Ebbw Vale.

Communicated by G. Parry, Junr. The iron is crystalline, as seen at the ends of the long narrow columns, which are 5 or 6 sided.

3272. Iron accumulating on the bottom of a blast furnace and forming the "bear" or "horse."

It shows a well-marked columnar structure. From the Ebbw Vale Iron Works.

3273. Iron from the furnace bottom at one of the furnaces at Elswick, Newcastle-on-Tyne.

Communicated by E. S. Noble, 1873. It has very large cleavage surfaces, which are cracked rectangularly and parallel to, or making equal angles with rectangular striæ. There are some large holes which have a golden tinge. Compare No. **3122.**

3274. Iron from furnace bottom at one of the furnaces at Elswick, Newcastle-on-Tyne.

Communicated by E. S. Noble, 1873. This, though from the same works, is not brilliant like the last, but has a kishy appearance. The cleavage planes meet obliquely and the striæ make angles of 60° with each other. The under surface is covered with graphite. Compare Nos. **3266, 3267.**

3275. Crystallised iron from the "bear" of a blast furnace.

It is very white, and shows columns ranged parallel to the top and bottom surfaces.

3276. Very columnar iron from the "bear" of a blast furnace.

The long narrow columns are parallel to the upper and lower surfaces. The iron is very white in colour. Some wrought iron made from this accompanies it.

3277. Piece of the old "horse" from Gwyther Forge, Abercarn.

It is a finely granular white iron. Produced by charcoal.

3278. Piece of an old "bear" from Bilston Furnaces, Staffordshire.

It shows a curved columnar structure, more or less perpendicular to the surface of the bear. It is produced by long continued heat. Communicated by S. H. Blackwell, 1856.

3279. Portion of a remelted "horse" from the bottom of a blast furnace at Wolsingham, near Darlington, containing an extraordinary proportion of silicon.

Communicated by Chas. Atwood, 1867. It has a peculiar grey lustre and is frothy and porous. It has been described by Dr. Percy in the Transactions of the Iron and Steel Institute. The furnace had been long in blast, and this was the last portion that melted on increasing the blast and adding coke and lime in order to clear out the bottom of the furnace. There was about 1 ton of this material. Sandstone, with iron diffused occurs in the furnace which might be reduced to silicon. It has been analysed by W. J. Ward and contains—

Silicon	15·378
Carbon	0·787
Phosphorus	0·113
Sulphur	0·088
Manganese	3·425
Copper	0·083
Nickel and cobalt	traces
Lime	0·424
Magnesia, alumina, &c.	traces
Iron (by difference)	79·702
	100·000

3280. Portion of a bear ? in a furnace of the Wigan Coal and Iron Co., Lancashire.

It consists of numerous small round blebs of metal, now coloured brown, imbedded in a matrix of blue earthy looking material, and is certainly not pure iron. On analysis it yielded—

Silica (including Silicon)	7·10
Total carbon	3·20
Manganous oxide	1·41
Lime	2·68
Magnesia	0·36
Phosphorus	1·30
Sulphur	0·50
Iron	84·26
	100·81

It has been re-fused under plate glass and the metallic portion has sunk to the bottom, and a brown glassy slag has formed at the top. The metal is of mottled iron, and consists of nodular fibrous crystals intercrossing at right angles.

Slags produced in the fining of Pig-iron to obtain Wrought Iron.

3281. Slag from the fineries at the Bloomfield Iron Works, Dudley.

This is composed of a number of interlocking large flat plates, whose surfaces are covered with numerous dull coloured rectangular pyramids which grow one over the other.

3282. Slag or tap cinder. From the finery at Bloomfield Works, Dudley.

This is covered with strong crests, composed of the angles of a number of overlapping pyramids, whose other edges stand out from the side.

3283. Large mass of slag or tap cinder from an iron finery. Locality unknown.

The surface of this slag is covered by numerous crests in the form of oblique rhombs, which are made up of a number of pyramids ranged in lines and overlapping, which gives them a grooved appearance, and each of these minor crests is itself made up of smaller pyramids. The body of the slag is compact, but crystalline in parts. It is divided into several partial layers by bands of gas holes, which are lined with a silvery coat, which also covers the crystals here formed. The under side is covered with excessively low oblong pyramids, the remoter parts of which are covered with the same silvery covering.

3284. Iron finery slag from an unknown locality.

The surface consists of large narrow crests, which are built up of similar plate-like crystals lying close together, the centre one extending furthest, Each plate is also complex and has the form of a very low pyramid. A section of the under side of this specimen has been taken for microscopical examination.

3285. Another specimen from the same mass.

This shows the same crest-covered surface, but the crests are composed of numerous pyramids, whose solid angles jag their edges as in No. **3282.**

3286. Another specimen from the same furnaces.

The surface is not here in crests, but in peaks, by the superposition of the pyramids round a vertical line.

3287. Another specimen from the same furnaces.

The broad surface of the thin plates or low pyramids seen in No. **3284** is here along the top of the slag, which is covered with these scale-like crystals.

3288. Another specimen from the same furnaces.

In this, which is a thinner mass, the low plate-like pyramids are arranged nearly parallel to the surface, which they merely ridge in different directions.

3289. Another specimen from the same furnaces.

The surface is covered by very narrow brilliant crests, standing vertically. They are the separate low pyramids, not combined into large ones as in No. **3284.**

3290. Finery slag from another furnace. Locality unknown.

It has several spiny outgrowths consisting of superimposed octrahedra.

3291. Finery slag. Locality unknown.

Its surface is covered with medium sized crests, which stand vertically. They are each composed of a complexity of linear crystals arranged obliquely.

3292. Calcined cinder from the mill. Locality unknown.

These are covered with numerous perfect pyramids belonging to the oblique system. They are coated with a brown deposit which renders the faces dull.

3293. Scoriaceous cinder. Locality unknown.

This is full of holes on the under side, but on the surface are numerous dull crystals of forms belonging to the rhombic system, mostly rectangular pyramids, but sometimes a combination of several forms.

3294. Calcined tap cinder.

A scoriaceous mass of inferior quality, containing 77·81 per cent. of ferric oxide and no ferrous oxide.

3295. Calcined tap cinder.

A scoriaceous mass of superior quality. It contains 86·48 per cent. of ferric oxide and a scarcely appreciable quantity of ferrous oxide. These two have been determined by R. Smith.

3296. Tap cinder.

Communicated by Mr. Kitson. Semi-scoriaceous below, but in the open cavities covered with brilliant black orthorhombic pyramids of small size.

3297. Tap cinder calcined. From the Brader Works, Oldbury, 1861.

A scoriaceous mass, all the cavities are lined with minute, but brilliant black crystals, in the form of orthorhombic pyramids. These are said to be of "iron olivine."

3298. Iridescent tap cinder from the Blaina Iron Works.

This appears to be partly composed of the sand of the hearth, on which was condensed here and there some blue material (salt of copper ?) passing at its edges to purple.

3299. Calcined tap cinder called "bull dog" when used for the bottom of a puddling furnace.

Burnt in a kiln at Ebbw Vale, 1865, according to Barrows and Halls patent. A scoriaceous mass with blue coated cavities.

3300. Calcined tap cinder or bull dog, broken up by crushing between rolls.

It is used in this state for fettling the puddling furnace.

3301. Crystallised slag in layers. Locality unknown.

In the centre the layers separate and crystals are formed, they appear to be octahedral, but are too ill-formed for determination, the whole has a bluish tinge.

3302. Mill furnace slag showing iron olivine crystals. From the Warrington Wire Company's Iron Works, 1871.

Contains minute iridescent crystals apparently of the rhombic system coating a shallow depression.

3303. Crystallised tap cinder.

Showing coarse vertical crests, each of which is serrated by the parallel edges of a number of overlapping skeleton pyramids (labelled 12a, stated to have been analysed by Dr. Percy, but it does *not* correspond to the No. 12 of his Report on Crystalline Slags).

3304. Crystalline tap cinder. Locality unknown.

The surface is composed of dark dull oblique pyramids like those of No. **3292.**

3305. Crystals on the surface of a tap cinder.

The bulk is slightly scoriaceous, on the surface are some isolated dull crystals showing very perfectly the double-ended oblique pyramids.

3306. Crystalline tap cinder.

Apparently calcined, being very scoriaceous, the small crystals coating the upper parts and the cavities. They consist for the most part of orthorhombic pyramids, truncated by basal planes. The figure is given in Dr. Percy's Report on Crystalline Slags (Brit. Assoc. Rep., 1846, p. 366), and is best seen in this specimen.

3307. Crystals of silicate of iron of the formula 2 FeO, SiO_2, on the surface of a finery slag.

From the collection of Col. Yorke. The slag is very thin and the surface is coated with projecting black crystals of the form of thin rhomboid plates.

3308. Crystalline tap cinder.

Showing tabular crystals of "iron olivine" bevelled by the faces of a pyramid.

3309. Magnetite crystals on the surface of a calcined heap of refinery forge and mill cinder from Blaina Iron Works, South Wales.

Communicated by Mr. Hoffman, 1858. They are in the form of rhombic dodecahedra, with brilliant faces.

3310. Stony mass in the form of a finery slag from Blaina Iron Works.

Communicated by C. Hoffman. It is dark and cavernous, the surface is covered with brown pseudomorphous oblique pyramids, many of which are skeletons, but they are not at all metallic when broken. With this is a large crystal, equally pseudomorphous, consisting of a double pyramid on an oblong base with an oblique axis.

3311. Spherical hollow globules of magnetic oxide of iron.

These are produced in large quantities in the fining of iron when jets of atmospheric air are made to impinge at a steep angle upon molten cast iron. They are strongly attracted by the magnet. Analysed by R. Smith.

Ferrous oxide - - -	28·91
Ferric oxide - - - -	37·44
Silica - - - -	24·10
Alumina, with small quantities of lime and magnesia, &c. - - -	9·55
	100·00

From the Blaina Iron Works, Cyfartha, South Wales. *See* Percy's Metallurgy, Iron and Steel, pp. 21 and 624.

3312. Shot-like slag projected from the finery furnace at the Bowling Iron Works, Yorkshire.

Communicated by Mr. Gilchrist, 1871. They are all of them hollow and black.

3313. Compact finery-slag, with a surface of small rhombic crystals referred to "iron olivine."

Very brilliant and iridescent; either plate-like or domed.

3314. Minutely crystalline piece of finery-slag.

Examined by Professor Miller, who reports the crystals to consist of octahedra of magnetite, with small needles, which are an aggregation of transparent crystals of the form of olivine, but they attract the magnet. Some of the magnetite crystals are a combination of the octahedron and rhombic dodecahedron.

3315. Group of crystals from a finery-slag.

These are the transparent plates of a brown colour, which cross each other. Examined by Professor Miller, who reports that they have the form of olivine, with a very distinct cleavage parallel to one face, but the angles differ slightly from those of ordinary olivine.

3316. Crystalline slag from the Urals.

A scoriaceous mass, with a few dark crystals like those of olivine.

3317. Crystalline slag from the Urals.

A very open mass of loosely aggregated crystals. They are black and brilliant, with the form of an oblique pyramid.

3318. Crystallised tap cinder from the iron works of the Steel Company of Canada, Londonderry, Nova Scotia.

Communicated by H. Louis. It is formed in the interior of some containing case, from which the compact portion crystallises radiately; the surface has numerous ill-defined brilliant crystals in a combination of the pyramid and basal plane, like those of olivine.

3319. Another example from the same source, more perfectly crystallised.

3320. Another example from the same source.

Some of the pyramids are truncated, some are modified into domes. The crystals are produced by allowing the tap cinder to cool slowly. They have been analysed by H. Louis, and are found to contain 54·34 per cent. of metallic iron and to consist of—

Silica	21·76
Alumina	3·21
Ferric oxide	5·64
Ferrous oxide	64·75
Manganous oxide	2·21
Lime	0·26
Magnesia	0·41
Phosphoric acid	1·83
Sulphur	0·23
	100·30

3321. Iron finery slag from Cujo, showing a crystalline surface.

Communicated by D. Forbes. This appears to be the mass whence No. **3314** was taken. It is compact below, and has a crystalline surface of minute aggregated octahedra of magnetite.

3322. Another specimen from the same source.

This consists of a compact mass below, with about 1 inch loosely crystalline, in serial portions of narrow plates and octahedra which cling to them, the plates crossing irregularly.

3323. Another specimen from the same source.

This is from the end of a flow. The plate or needle-like crystals are confined to the under surface and the compact portion, and the octa hedra alone cover the upper surface, where they are very minute. The olivine seems to form where there is least access of oxygen, the magnetite where there is most.

3324. Finery slag from Blaina Iron Works, Newport, Monmouthshire.

Communicated by C. Hoffman. It consists of brilliant black crystals of orthorhombic pyramids, which are in some cases slightly oblique.

3325. Another example from the same source.

This is the mass from which the portion examined by Professor Miller was taken, No. **3315.** It consists of intercrossing plates.

3326. Crystalline finery slag ? Locality unknown.

Consists of fibrous radiating crystals of a brilliant black colour, with a very irregular surface.

3327. Finery slag showing crystals of magnetite from a foreign locality.

In well developed, dull octahedra.

SLAGS PRODUCED IN THE PUDDLING FURNACE.

3328. Refinery cinder produced in puddling cast iron to form steel at the Ebbw Vale Iron Works, 1865.

The slag is thin, and has an upper surface composed of very thin vertical plates, scarcely crystalline in shape; imbedded amongst them are some several spherical shots of iron.

3329. Bottom of a puddling furnace, at the Low Moor Iron Works, Yorkshire, 1868.

This shows the total thickness of the bottom. It is porous in the interior.

3330. Refinery slag from the Bromford Iron Works, near Oldbury, 1845.

One piece is a solid mass with a crystalline coating in one place; the crystals not very brilliant combinations of rhombic dodecahedra with the octahedron, or of the cubic system, with possibly some rhombic crystals. The other pieces are covered with very minute brilliant crystals, some being prisms, others octahedra.

3331. Refinery slag from an unknown locality.

These show very large crystals more than half an inch in length, consisting of a rectangular pyramid, modified by a basal plane, as in the crystals of iron olivine, seen in No. **3320.**

3332. Slag from an unknown locality.

A thin compact mass, with crystals standing vertically to its surface, which are flat rectangular plates, with the edges bevelled by the sides of a pyramid.

3333. Refinery cinder from the Bromford Iron Works, near Birmingham.

Communicated by J. Dawes, 1845. This appears to be No. 13 of Dr. Percy's Report on crystalline slags to the British Association, 1846. It is there stated to be from the flue of a puddling furnace, where it had been exposed to a high temperature for a considerable time. The surface is covered with brilliant iridescent black crystals, having the form of thick plates, with the edges bevelled by the sides of a pyramid, or ocasionally of a prism. They belong to the rhombic system. An analysis of this slag by Dr. Percy gave—

Silica - - - -	29·60
Ferrous oxide - - -	48·43
Ferric oxide - - - -	17·11
Manganous oxide - - -	1·13
Alumina - - -	1·28
Lime - - - - -	0·47
Magnesia - - - -	0·35
Phosphoric acid - - -	1·34
Sulphide of iron - - -	1·61
	101·32

See also Percy's Metallurgy, Iron and Steel, p. 668.

3334. Refinery slag from the Bromford Iron Works, Oldbury, 1845.

Communicated by J. Dawes. An outgrowth of brilliant iridescent black crystals, each having the form of a skeleton rectangular pyramid, and so overlapping and combined as to form other complex pyramids. The crystals are essentially of the same character as in the last.

3335. Refinery slag from the Bromford Iron Works, Oldbury, Birmingham, 1845.

Communicated by J. Dawes. This is a very thin cake, with bits of stone and sand imbedded on one side; on the other it is clothed with brilliant black crystals in the form of more or less skeleton octahedra, *i.e.*, belonging to the cubic system.

3336. Refinery cinder from the puddling furnaces of the Ebbw Vale Iron Company.

A scoriaceous piece of the bed, with the bubbles on one side pulled out into long tubes perpendicular to the smooth surface.

3337. Crystallised cinder from the bottom of the puddling furnaces at Dowlais, South Wales.

Communicated by E. Riley, 1856. It consists of a number of thin mica-like brown plates standing vertically to the surface. The faces are striated with lines which form a hexagonal; apparently belonging to the rhombic system.

3338. Miscellaneous refinery slags from the Bromford Iron Works, Oldbury.

Communicated by J. Dawes. Several show very well the dull double rectangular pyramids which are here isolated. The more transparent ones show a deep brown colour.

3339. Refinery slag from Messrs. Solly's Works, Tividale. Obtained at the Dudley Museum.

Communicated by Mr. Twamley. Of the four pieces, three have a number of crystalline outgrowths produced by the overlapping of skeleton octahedra. The fourth, which has a thicker and more irregular basis is composed of the rectangular pyramids. The two systems of crystallisation are both represented here. A specimen is referred to by Dr. Percy in his report on Crystalline Slags, 1846, and in his Metallurgy, Iron and Steel, p. 669, as communicated by Mr. Twamley, for the Bloomfield Iron Works, Tipton. The fourth of these specimens may be the one there referred to.

3340. Crystalline slag from a puddling furnace at New Bradford, Massachussets.

Communicated by Josiah Cooke. This has large crystalline plates standing vertically from the surface. They are composed of very thin plates, aggregated into groups or formed to build up a very low rectangular pyramid. They are also dotted all over with little hexagonal plates of equal hardness with the rest.

3341. Another specimen from the same locality.

This shows the plates aggregated in parallel lines which combine to form larger plates with the edges truncated by rectangular pyramids of a higher angle. The little scales are arranged in the intervals. The lower pyramids are seen on the other side.

3342. Refinery slag from the Bromford Iron Works, Oldbury.

Communicated by J. Dawes. A very compact slag with an even surface sparkling with small crystals which have the octahedral form of magnetite.

3343. Slag from a Siemens' steel-melting furnace. From the Dowlais Furnace, 1871.

This furnace was allowed to cool down with the charge in it. Communicated by D. Watson. These are nearly transparent thin mica-like plates of a siliceous slag, obtained in smelting the steel direct from the ore.

3344. Refinery slag from an unknown locality.

This has an arborescent growth composed of innumerable small well developed octahedra. Associated with these are some long prismatic crystals of small size.

3345. Slag from the melting pots of steel when manganese was used.

Communicated by E. F. Sanderson, Sheffield, 1857. It is a semi-translucent green glass with cavities.

3346. Crystalline slag from a steel furnace from Cheddle.

Communicated by W. W. Smyth. The crystals are large and have the form of a rather low rectangular pyramid, but they have their edges rounded and possess a peculiar silky lustre, owing to the striation of their surfaces, though they are brilliant within. Another specimen shows thin and brilliant plates. On analysis they have yielded—

Silica - - - - -	48·98
Alumina - - - -	8·01
Ferrous oxide - - - -	30·93
Manganous oxide - - -	9·24
Lime - - - - -	5·60
	102·76

3347. A crystallised mass of iron silicate produced from the smelting of forge cinder and coal to make "bull dog."

A very large heap of forge and other cinder was mixed in alternate layers with pieces of coal, and the whole was ignited. It failed to produce a suitable "bull dog," and the heap became an agglomerated and worthless mass, which could only be broken up by blasting. At the Blaina Iron Works, 1859. The drusy cavities of the mass are covered with brilliant black crystals having the form of oblique pyramids on a rectangular base.

3348. Iron slag from an unknown locality.

From some refining process. It is a black heavy mass with one side coated with dull crystals having the form of a rectangular pyramid of the rhombic system.

3349. Iron slag, locality and process unknown.

It is a dark compact mass, with innumerable crystal needles crossing in every direction. Its surface shows similarly intercrossing crystalline plates with no well-defined outline.

3350. Fused oxide of iron taken from the regenerator of one of the furnaces at the Landore Siemens' Steel Company's Works, near Swansea.

Communicated by A. Willis, 1872. A thin mass of slag-like material with an irregular surface coated with a bloom of excessively minute crystals.

3351. Mass of iron slag melted and poured into a cardboard box.

It shows a crystalline surface in the centre, composed of very finely arborescent minute octahedra. Locality unknown.

SLAGS FROM THE REHEATING FURNACE.

3352. Flue cinder from the Low Moor Iron Works, 1876.

A moderately thin mass, quite compact, with crystallisation crossing in lines from top to bottom. It has a bluish tinge of colour. The flue cinder is the material that flows out from the reheating furnace into the flue from whence it escapes.

3353. Flue cinder from the Low Moor Iron Works, Yorkshire, 1868.

This has a narrow band of scoriaceous matter on one side; the rest is composed of radiating crystals, which aggregate on the drusy surface in sheaves of the form of bevelled plates, leaving each with a skeleton structure.

3354. Slag from the reheating or so-called balling furnace at the Melton Iron Works, near Wentworth, Yorkshire.

Communicated by W. W. Smyth. It contains small rhombic crystals in the cavities.

3355. Flue cinder from Mr. Beasley's Furnaces, Smethwick, near Birmingham, 1851.

A metallic-looking mass with large cavities, the interior of which is lined with crystals. These are the plate-like rhombic crystals with the edges bevelled by a rectangular pyramid, as in No. **3340.**

3356. Iridescent flue cinder from Barrows and Hall's Furnaces, Tipton, Staffordshire, 1846.

A compact mass, with the under side containing numerous imbedded stones and rubbish, the upper side smooth and shining from the surfaces of numerous small crystals, when seen by reflected light at a certain angle. The larger of these crystals have the form of an excessively low rectangular prism, whose vertical height, in fact, is approximately zero, and only marked out by its division into four triangles, the alternate pairs of which have a distinct colour, either blue or pink; the smaller crystals are hexagonal on the outside, flat, and of a golden iridescence.

3357. Another piece of flue cinder similar to the last.

Probably from the same source. The crystals on the surface are larger and less iridescent. They are all striated parallel to the base of the pyramid.

3358. Iridescent flue cinder. Locality unknown.

The iridescence in this case is from bluish to yellowish-green. It is confined to crystals showing the pyramidal faces. Those which show the edges are greyish-brown.

3359. Piece of flue cinder from an unknown locality.

Like the next, but smaller. The angles of the smaller piece have been measured by Mr. Brooke. The angle between the faces which are parallel to the longer diameter (*i.e.*, that have an obtuse angle at their apex), is 168° ; that between the other faces is 173° 72′.

3360. Piece of flue cinder showing a crystalline surface. Locality unknown.

This has a single large crystal for a surface of more than a square inch. It is the exceedingly low rectangular pyramid seen in No. **3356.** Each face is built up with partial lines running parallel to the slanting sides.

3361. Flue cinder from the reheating furnaces of Messrs. Bramah, Barrows, and Hall, 1846.

A thin rather brassy looking compact mass, lined transversely, but showing no obvious crystals. One side is puckered like the surface of a flow, the other has a carpet as of very minute interwoven needles, which are in reality the cross section of their micaceous plates, standing vertically to the surface and producing the transverse lines on the sides.

3362. Masses of scrap iron found on the floor of the reverberatory reheating furnace at the Highfield Works, Bilston, 1881.

These pieces were all found imbedded in the cinder of the charging hearth at about its centre, and immediately opposite the charging door. The bright parts of the iron were under the blow holes or craters in the cinder, but on the uppermost sides of the specimens, as found in the hearth. Communicated by J. R. Wheeldon. No. 1 was the first specimen found on 20th of June 1881. It has been lacquered to prevent its being tarnished. The white spaces show no crystalline surface, and two or three of them are divided into parts, as a soap bubble is divided by liquid partitions, so that they appear like flattened gas cavities in a liquid. The scrap is perforated at two points, and on the back is black and nodular. No. 2 has one very large patch which is very flat. It is covered by the finest arborescent crystallisation. On the other side the

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surface is covered with little pustule-like elevations, with slag in the depressions. No. 3, found four days later, shows the same arborescent crystallisations, both in the bright and dull parts, of which the former have tarnished pink. It is still adhering to the cinder which is scarcely melted at an inch distant, then it becomes greenish and compact, but spongy, only at one place changing to a glass, where it passes to the other side on which lies a mass of glass occupying the dull areas, the bright ones being the continuation of the walls of gas cavities in the glass. No. 4 has in like manner some black glass fitting to the dull portions, while the bright ones correspond to its cavities. The other side has only pustules and slag. No. 5 closely resembles No. 2. It would thus appear that the heat had melted the slag above the piece of scrap into glass and produced large bubbles of gas, which being prevented from escaping have had an effect upon the iron. Compare No. **3283.**

Special Processes in the Production of Iron.

3363. Specimens illustrative of Blair's process for refining pig-iron by aeration, by causing it to drop down a series of inclined steps as it flows from the blast furnace.

Communicated by S. Blair, 1866. No. 1 is a sample of the pig-iron used. It is smelted with coke from Lake Superior specular ore, and fluxed with a limestone not previously used for blast furnaces. It is so strong in body and so difficult to puddle that only two heats could be made without stopping work to restore the fixing and bottom. It is excessively fine in the grain. No. 2 is the same pig-iron as No. 1, but after it has been remelted in a cupola and poured down the inclined steps. This is found to work freely and more easily than ordinary coke pig-iron. It has a coarser structure. No. 3 are small tears of pig-iron poured gently into water. This was the ordinary metal used at the foundry. It requires, of course, remelting. No. 4 has also been poured into water, but has been dropped from a distance of 18 feet through the air before reaching it. The metal is all torn into agglutinated shreds.

3364. Specimens illustrating Taylor's process of stamping and assorting puddled balls.

This process was patented in 1859, and carried out by Mr. Davis at the Low Furness Iron and Steel Works, Ulverstone, but has since been abandoned. No. 1 are two large lumps of puddled ball of a very open character. In this method these balls, instead of being shingled and rolled at once, are allowed to cool, then broken up under steam stamps, and then passed under rollers over a riddle, to separate the larger pieces from the smaller. These larger pieces, No. 2, are those which have been imperfectly puddled, and are called unwrought pig. They are returned to the puddling furnace, and are metallic in appearance, and of the size of marbles. The smaller pieces, No. 3, which pass the riddles, are more cinder-like in appearance. They are balled up and hammered, as with ordinary iron. *See* Percy's Metallurgy, Iron and Steel, p. 688.

3365. Illustrations of the process of smelting iron in the north of Spain.

The ore used is the Camponel ore, a red hæmatite (1). This is mixed with a grey compact limestone found in the neighbourhood, (2), and some black refining cinder (3) and Durham Coke. This compound is smelted in a hot blast furnace, the hot blast having a temperature of 350° C. only. From this is produced the piece of pig-iron (4), with a coarsely crystalline fracture, and the pieces of greenish-grey compact slag (5). This pig is afterwards refined into bars (6), about 1¼ in. square, which, on bending and cutting, shows a fine fibrous fracture. Manufactured at Messrs. Ebarrows Iron Works, at S. Nicholas on the River Mervion, near Bilbao. Communicated by W. E. Bell, 1872.

3366. Illustrations of Chenot's process, for the direct extraction of iron from its ores. From Ebarrows Works, S. Nicholas, near Bilbao.

Communicated by W. E. Bell. The ore used is a brown oxide from Somerostro, near Bilbao, known as Galeria ore, from its being worked underground, in galleries (1). This is mixed in the process with charcoal dust in excess, and the whole heated to a comparatively moderate temperature, so as to reduce the iron oxide. It is then extracted from the base of the furnace in lumps (2), which are of a spongy character. This is used for the purpose of making steel, for which it has to be carbonised and compressed; a resulting bar is seen in (3). For an analysis of the ore used, and a description of the processes of reduction and carburisation, *see* Percy's Metallurgy, Iron and Steel, pp. 335 and 776.

3367. Iron ore reduced by Chenot's process, by Chenot himself.

Procured at the Paris Exhibition in 1855 by W. W. Smyth, who was on the jury of the Metallurgical Department. It has been hammered out on one side into a projecting nail to show that it is malleable metal.

SAMPLES OF WROUGHT IRON.

3368. Partially puddled ball of iron from the Bromford Iron Works.

A scoriaceous looking mass.

3369. Specimen of "puddled bar" from the Bromford Iron Works, Oldbury.

Communicated by J. Dawes.

3370. Series of specimens of various qualities of wrought iron.

Communicated by Mr. Davies. The piece marked with A is called "plating" iron, that marked with R on one side and D in a circle on the other is "red short," that marked "GR" is good rivet iron, that marked with C and which is cracked is "cold short," that with M is "melting" iron.

3371. Sample of Marshall's Iron used for gun barrels. Manufactured at Wednesbury, 1855.

Communicated by S. H. Blackwell. This iron is used with great success for the coils of the Armstrong guns at the Arsenal at Woolwich.

Much sounder welds have been obtained with it than with Taylor's (of Leeds) iron previously used at the Arsenal. The fracture is said to be remarkably clear and uniform. It is marked with the name "John Marshall."

3372. Portion of a bar of "best iron" from the Cyfartha Works, South Wales.

Made in 1859, and punched with a square punch while hot.

3373. Sample of best rivet iron.

Melted in a steel melting pot, and cast into an ordinary ingot mould, and then tilt-hammered and polished on one side.

3374. Bar of anthracite iron. Manufactured at the Ystalyfera Furnaces, South Wales.

It has about 1 square in. section and was tested in a bar of 4 ft. length. The breaking strain was 651 lbs. per square inch.

3375. Bar of iron made from Shropshire and Welsh iron ores, with the cold blast.

It is forged, and has a breaking strength of 1,310 lbs. per square inch.

3376. Iron made at Coalbrook Vales, South Wales, from ore containing capillary pyrites or sulphide of nickel.

Communicated by S. H. Brackwell. The nickel is not recognizable in the iron.

3377. Pieces of cold short iron, broken by bending.

3378. Two pieces of rivet iron, one bent and broken, the other cut and showing fibrous.

3379. Series of samples of bar iron, marked with various marks.

1 is marked with 3 G's in circular stamps; 2, has an oval with KC?; 3, has a monogram; 4, has an S enclosed in two circles; 5, has a G and Sykes; 6, has monograms of HK in two beaded circles; 7, has an illegible monogram; 8, has D————n; 9, has L and Sykes; 10, has an arrow and small circle in one circle and P. D. in another; 11, has O.O.; 12, has 1845, BGS, CCND in two square depressions; 13, has a monogram composed of F. H. L. & D; 14, has a monogram composed of V. K. H; 15, has K, with an arrow capped with small circle, and the word Lancashire; 16, has a crown, CB and a monogram composed of A and M; 17, is a little blistered, but has the same marks as No. 9; 18, has I. C. P; 19, has B ° in a circle; 20, has E with the word "best" on it in smaller letters and also a crown; 21, is marked with a crown and G below it; 22, has the letter G; 23, has S, in two concentric circles with dots between; 24, has two plain circles; 25, is marked with LW; 26, has 1845, HMS CCND in square depressions; 27, has GBW; 28, has GK; 29, has a crown with C below;

30, has two crossing arrows with N on one side and B on the other; 31, has three crossing hammers; 32, has SH in one circle and L 6 (?) in another.

3380. Square wedge of wrought iron bent upon itself without breaking.

3381. Piece of Low Moor iron marked II., and broken from the finished bar.

Communicated by H. B. Woodcock.

3382. Small pieces of iron used in the "Welch Furnace."

3383. Piece of bar iron from the furnaces of Okeby, near Dannemora, Sweden.

3384. Refined iron from the Bromford Iron Works, 1856.

There were two twyers working on each side. The mass is very compact and finely crystalline like white iron and has a layer of silicate of iron scoria with rhombic crystals on the surface.

3385. Piece of metal from the common iron refinery, from Cyfartha, South Wales, 1859.

It is mammillated all over and porous, showing the escape of air from all parts of its surface.

3386. Fused wrought iron made directly from calcined Welsh ore.

It is very white and bright and largely crystalline, and is accompanied by some green transparent glass as slag.

3387. Sample piece of rail iron.

3388. Sample piece of binding iron, marked with a dog and the word Millwall.

3389. Sample of forged iron for etching. From Walker's Works, Leeds.

Two rods have been made to overlap, and the overlapping portion where double has been hammered down to the single thickness or less.

3390. Three samples of iron analysed for the Special Committee on Iron, 1873.

See the Report of this Committee, p. 46. The sample marked A. was unannealed; the sample B. was the same annealed, and the third is No. 2 French Iron. The analysis by C. Tookey of the three shows—

	A.	B.	2.
Carbon - - -	0·19	0·21	0·29
Sulphur - - -	0·02	0·03	0·02
Phosphorus - -	0·25	0·24	0·03
Silicon - - -	0·17	0·16	0·09

Manganese and cobalt -	0·09	0·07	0·06
Iron - - -	99·28	99·29	99·51
	100·00	100·00	100·00

See Percy's Metallurgy, Iron and Steel, p. 741.

3391. Bar of iron made from common Scotch iron with common scrap iron and old steel wire rope.

Communicated by W. C. Cambridge. It has a small fibrous fracture.

3392. Sample of cable bolt iron, half a pound of which has been fused under cinder, with pieces of quarter inch bar made from it by welding and hammering.

3393. Piece of iron from Sheffield. Analysed by F. A. Abel.

The components other than metallic iron are 2·63 per cent. of carbon, 8·20 of silicon, 0·70 of phosphorus, 0·10 of manganese, 0·02 of sulphur.

3394. Surface of mass of refined iron. Made at the refineries at Cyfartha, South Wales, 1859.

The specimen is very scoriaceous, the holes being smaller and more numerous at the surface. Many show the variously coloured tarnishings which are characteristic of the different tempers of steel.

3395. Small bar of best iron, broken cold.

Made at the Cyfartha Iron Works, South Wales, 1859. It has a very finely fibrous structure.

3396. Piece of a puddled ball, heated by the waste gases of the blast furnace.

Communicated by Mr. Lewick, 1860. It shows a minutely mammillated irregular surface.

3397. Three bars of iron, one polished, another worked up at one end, the other showing parallel bundles of fibre, and the third rusted and showing a stratification in cross section, by the greater or less erosion of the laminæ.

3398. Bar of wrought iron from the Garjenberg Iron Works, Sweden.

Marked with L.G.I.

3399. Bar of wrought iron from Horsdall (?) Iron Works.

Marked with a device like a tree in a circle of small knobs.

3400. Piece of wrought iron in the form of an irregular bar, from Creshevo, Bosnia.

Communicated by Vice-Consul J. Z. Mostar.

3401. Bar of wrought iron worked at Dunbar Forges, Pennsylvania.

Bent, cut, and broken, but so as to show the fibrous fracture.

3402. Wrought iron bar worked at the Dunbar Forges, Pennsylvania.

Bent cold, and the ends brought into contact.

Special forms of Iron.

3403. Specimens of sheet iron from the Cwm Avon Iron Works.

Sent to the International Exhibition in 1862 by W. P. Struvé. About 80 of these sheets go in the thickness of an eighth of an inch.

3404. Larger specimen of the same thin rolled iron.

Communicated by W. P. Struvé.

3405. Thin sheet iron.

Communicated by J. D. Clare, 1876. Tested by W. J. Ward; its thickness is ·0015 to ·00175 of an inch.

3406. Thin sheet iron manufactured in Russia.

Communicated by R. Damon. It was produced at Nijri Taguil in 1878, at the works of P. P. Demidoff Prince San-Donato. It is a specimen piece bearing this inscription.

3407. Russian sheet iron.

Described by Dr. Percy in the Transactions of the Iron and Steel Institute.

3408. Three coils of iron wire, one of which having a rectangular section has been tested for tensile strength.

From J. Longridge, 1886. These have been received from Germany. The rectangular one broke only under a strain equal to 140 tons per square inch, and it has been found to have a modulus of elasticity = 13,500 tons, so that the elastic limit is very nearly the same as the breaking strain.

3409. Specimens of bright wires which have been subjected to trials for breaking strain.

3410. Specimens of wire, one of which has been drawn only, the other has in the lower part been twisted and shows the spiral running of the fibres on the surface.

3411. "Malleable cast iron."

Produced by heating cast iron in contact with its oxide. Communicated by Mr. Cowper, 1865. *See* Percy's Metallurgy, Iron and Steel, p. 805.

IRON SUBJECTED TO SPECIAL TREATMENT.

3412. Piece of Swedish iron which has been subjected to exceedingly rapid and intense hammering, whereby it has acquired the texture of steel.

It is marked with an S with a bar across it, in a circle of dots. Communicated by Mr. Keiller from his iron works, near Gothenburg, Sweden, 1848.

3413. Pieces of iron cut out of an ingot of best Swedish iron melted in a crucible in a furnace heated by Crampton's coal-dust process.

64 lbs. were melted in one pot. Communicated by Mr. Crampton, 1871.

3414. Piece of a $\frac{5}{16}$ inch square bar of iron melted in 20 minutes, reckoning from the time of the commencement of red heat.

The crucible was completely filled and the cover luted.

3415. Pieces of $\frac{5}{16}$ inch square bar of iron, partially melted in 11 minutes from the time at which red heat commenced.

3416. Wrought iron which has been melted under plate glass, and then etched with acid to show its crystalline structure.

This structure is excessively minute, but appears to consist of innumerable microscopic octahedra.

3417. Piece of nearly round rolled bar-iron which has been exposed for a considerable time in a pot of melted glass.

Communicated by Dr. Faraday, 1849. The whole surface, as well as the interior where not covered by black scale, is seen to be composed of loosely arranged arborescent crystals, built up of overlapping octahedra. *See* Percy's Metallurgy, Iron and Steel, p. 3.

3418. Piece of flat bar-iron which has remained for a long time in a glass pot.

Communicated by Mr. Sopwith, who obtained it from Jos. Sewell. It is presumed that the specific gravity has increased. This is not properly crystalline, but is divided into numerous columns by jointing. Where the surface is not covered by black scale it is marked with an hexagonal irregular network joining the boundaries of the columns, which in transverse section are seen to stand perpendicularly to the surface, and meet in a nearly median zigzag line. The joint surfaces are very bright and silver-like. *See* Percy's Metallurgy, Iron and Steel, p. 3.

3419. Test piece of iron as used at the Royal Arsenal, Woolwich, in 1878, for ascertaining the tensile strength of the metal.

The piece is turned to a smaller diameter in the centre than at the ends, and then the two ends are pulled in opposite directions. These two pieces have been torn asunder, after stretching, and fit when put together. Each is marked "$\frac{\text{H.}}{\text{B.R.}}$ 4 A. 150 8^3 15/10/68."

3420. Specimens cut from a 4½ inch square bar of "Bessemer Swedish Iron" and tested for strength.

The diameter of the tested portion in the centre of each is ·754 inch, and the length of the same 2 inches. The proportion of carbon in these samples is 0·15 per cent. One is marked 1. M. S. — R. No. 7068 — L. This is soft iron; it began to yield at a tension of 12·4 tons; it lengthened ·78 in., and broke under tension of 23·8 tons. The one marked 2 M. O. — R. No. 7069 — L. was tempered in oil; it began to yield with 19·8 tons tension, it lengthened 0·702 inch, and broke under a tension of 30 tons. The one marked 3 M. W. — R. No. 7070 — L. was tempered in water; it began to yield with 19·8 tons tension, it lengthened 0·77 inch, and broke under 30·5 tons tension. Communicated by Mr. Frazer. A sample of the unworked iron accompanies these.

3421. Square bar of iron which has been etched by dilute sulphuric acid.

This brings out the fibres on all sides, showing they are separated by more easily soluble metal.

3422. Malleable iron which has been melted in a crucible and then etched with acid.

It shows only irregular crevices.

3423. Piece of a wrought iron crowbar, indented and broken by a steel Nordenfelt bullet at the Royal Arsenal, Woolwich.

It shows the fibrous structure of the iron and the crystalline fracture produced by sudden breakage. Communicated by F. L. Nathan.

SPECIAL PROCESSES OF STEEL PRODUCTION.

Bessemer Process.

3424. Pig of Bessemer iron, used for the manufacture of steel, produced at the West Cumberland Hæmatite Company's Iron Works, 1869.

3425. Crystals formed in the centre of a pig of Bessemer iron.

Communicated by C. Tookey. They are fine mica-like metallic plates of a yellowish white tinge.

3426. Piece of an ingot of iron tapped off from an experimental working of Bessemer's process at Baxter House, St. Pancras Road, August 1856.

This was the date of Bessemer's paper on his process to the British Association. The metal is silvery white and crystalline in fracture, the crystals belonging to the cubic system, and sometimes showing a combination of the cube and octahedron. It has been shown to contain over 1 per cent. of phosphorus. *See* Percy's Metallurgy, Iron and Steel, p. 815.

3427. Piece of Bessemer iron produced experimentally in 1856.

Communicated by Captain Margessen. It is white and crystalline, and contains many gas cavities variously tarnished. It is said to have been analysed in Dr. Percy's laboratory by A. Dick. In his volume on Iron and Steel two analyses of Bessemer iron by C. Tookey are given, p. 819, but there is no indication whether this specimen is either of those analysed.

3428. Piece of the same iron as the last which has been compressed to show how it can be worked up.

3429. Piece of Swedish iron melted, hammered, and rolled to compare the fracture with that of a similar piece of Bessemer metal.

Communicated by Mr. Bessemer, 1856. Its fracture is granular and fibrous as contrasted with the crystalline fracture of No. **3428.**

3430. Iron made at Carlsdahl Iron Works, Nericia, Sweden, by Bessemer's process without spiegeleisen.

The pig-iron used is made from Vibel ore which contains 5·38 per cent. of manganous oxide. It is a small bar with Carlsdahl impressed on it. Communicated by C. Sandberg.

3431. Round ball of slag of low specific gravity obtained from a Bessemer converter.

From the International Exhibition of 1862. It is a porous mass covered with small crater-like holes.

3432. Piece of crystalline slag from the Bessemer steel works of Fagusta, Sweden.

The form of the crystals in a drusy cavity is that of thin plates of a rich brown colour. The mass has a radiating structure perpendicular to a glassy saalband. Communicated by the Boiler Commission.

3433. Slag thrown out of the furnace during the time of the "boiling" in the Bessemer process, 1856.

It consists of separate small light pieces of black scoria.

3434. Slag ejected from a Bessemer converter.

Obtained in 1876 at Cammel & Co.'s. Works, Sheffield. It is a light cindery black mass with large internal cavities, and with small interspersed globules of metal.

3435. Iron which accidentally escaped from the furnace during the experimental operation in 1856 of Bessemer's process before the blowing through of the air was complete.

It is in the condition of white iron.

3436. Asbestos-like slag found in the chimney of the Bessemer furnace at Sundvikin, Sweden.

It is there called "Bessemersull" and is probably the ordinary slag blown into filaments by the blast, like furnace wool. It is black and in very fine and short pieces. Communicated by Dr. Stapff, 1864.

3437. Iron tapped off after the process of blowing air through it is completed.

Obtained in the experimental operation of Bessemer's process in 1856. It is bright, highly crystalline, and with numerous cavities of different iridescent hues. *See* No. **3394.**

3438. Steel experimentally produced by Bessemer's process in December 1856.

The iron operated on at Dowlais furnaces was good common white pig made from two parts of Dowlais Welsh mine, one part of red ore and one part of cinder. The Bessemer process was carried out in a furnace exactly similar to that used by Bessemer himself at Baxter House. It was run from the furnace into a sand mould, cooled, re-heated rather below the usual temperature for rolling rails, rolled and broken in pieces. One of the pieces was squeezed under the squeezer, which required a certain amount of humouring and then rolled through puddled rolls into a bar about 8 ft. long. It is highly crystalline and very brittle. Communicated by E. Riley.

3439. Steel experimentally produced by Bessemer's process in June 1857.

The pig-iron operated on was produced from a charge of half Blaenaw and half Cleator Moor hæmatite. It may by hammering carefully be drawn out very thin, but in its present state it breaks easily across and has a coarse scaly crystalline fracture. Communicated by J. H. Henry, analyst to Bessemer.

Thomas-Gilchrist Process.

3440. Basic brick used for lining Bessemer converters in this process.

In small fragments. It is made into a lining of the converter, and after the decarburization by Bessemer's blast is finished, dephosphorization of the pig-iron takes place during the "after-blow."

3441. Cake of blown metal and cinder from the Blaenavon Works, South Wales.

Produced in the Thomas-Gilchrist process of making the No. 3 steel bar (**3444**).

3442. Pig-iron used to make No. 3 steel at Blaenavon Iron Works, by the Thomas-Gilchrist process.

3443. Bar of steel made by Thomas-Gilchrist process at Blaenavon Ironworks, and bent cold.

Made in a 3 cwt. converter, lined with rammed limestone and silicate of soda, from pig-iron containing 1·4 per cent. of phosphorus.

It is rather coarse in the grain, but is completely bent upon itself without breaking.

3444. Square bar of No. 3 steel, made at Blaenavon Iron Works, bent cold.

Made from pig-iron containing 1·4 per cent. of phosphorus, in a 3 cwt. converter, lined with basic bricks (No. **3440**), set in a cement of magnesian limestone and silicate of soda, and 20 per cent. of basic mixture; two of lime to one of "Blue Billy" was added cold.

3445. Piece of phosphorized wrought iron found in the slag from a basic converter, at the Staffordshire Steel and Ingot Iron Company, Bilston.

It was poured off during the "after blow," when for some special reason the converter had to be turned down and the slag poured. On analysis this shows 1·05 per cent. of phosphorus, ·30 per cent. of manganese, ·03 of silicon, and ·07 of carbon. It has a very brilliant, flaky, fracture. Communicated by F. W. Habord.

3446. Piece of the above phosphorized wrought iron worked up into a double flange at one end and into a point at the other, to show how well it works when hot.

3447. Phosphide of iron thrown out of a basic converter in the Thomas-Gilchrist process of steel making, 1885.

It is very crystalline, and has two well marked cleavages oblique to each other. It contains 1·05 per cent. of phosphorus, ·03 per cent of silicon, and ·07 per cent. of carbon, and ·30 per cent. of manganese, the rest being iron. It has been found after forging, to have a tensile strength of 5 tons per square inch.

3448. Cinder produced in making No. 3 steel, by Thomas-Gilchrist basic process.

It is a greenish-black scoriaceous glass.

3449. Basic cinder produced in the Thomas-Gilchrist process at the North-eastern Steel Works.

Communicated by E. Riley, 1885. A light thin mass with gas cavities, and a tendency to a columnar jointing. Analysed by E. Riley; yields—

Silica - - -	6·15	
Ferrous oxide - -	14·19	=14·37 iron.
Ferric oxide - - -	4·75	
Manganous oxide - -	4·65	
Alumina - - -	1·19	
Lime - - -	41·37	
Magnesia - - -	9·50	
Phosphoric acid - -	18·15	=7·92 phosphorus.
Sulphur - - -	0·16	
Calcium - - -	0·20	
Vanadium oxide - -	0·66	
	100·97	

3450. Crystals produced in the kilns when burning the basic bricks used to line the Bessemer converters in the Thomas-Gilchrist process, at Blaenavon Iron Works, South Wales, 1878.

These have been examined by Professor Maskelyne, and pronounced to be Diopside. They are in long, grey, narrow crystals, radiating irregularly, and forming the whole substance as in actinolite. In one specimen they form the substance of a stalactite.

All these specimens (except Nos. **3445, 3446**), illustrating the Thomas-Gilchrist process were communicated by Percy C. Gilchrist in 1878.

Siemens' Process.

3451. Dinas brick, which has been used in the interior of a Siemens' regenerator.

It has, to a large extent, melted and flowed down in a long stalactitic drop.

3452. Balls of slag produced in a steel-melting open hearth furnace, at the Fallside Steel Works of the Steel Company of Scotland, Glasgow.

They are almost perfectly round, about 1 inch in diameter. They form in almost every pour of slag. There is a more or less feebly marked radial, platy crystallisation, but they are not properly spherulitic. One sample shows them in process of formation. Communicated by F. W. Paul, 1887.

3453. A piece of the ordinary slag which accompanies the last specimens, and in the midst of which they are formed.

It has a peculiar radiating cleavage, as though it were itself part of a large ball. On analysis the slag yields—

Silica	56·10
Ferrous oxide	23·61
Alumina	3·86
Manganous oxide	9·84
Lime	6·10
Magnesia	0·76
	100·27

3454. Stalactite hanging down from the roof of a Siemens' steel-melting furnace, at Landore, 1870

It is derived from the same Dinas bricks as No. **3451.**

3455. Slag produced in a Siemens' steel-melting furnace, at Dowlais, South Wales, when the furnace was working cold.

It is a green glassy cinder, full of holes.

3456. Series of samples of metal in the process of its conversion from pig-iron into steel by Siemens' process, through the addition of scrap iron and manganese.

No. 1 is the melted Askham and Barrowskulls' pig-iron. No. 2 to No. 9 are samples after each successive addition of 6 cwt. of scrap iron to the charge. This scrap is tin-plate scrap. No. 10 is produced after the addition to each cwt. in the charge of 8 lbs. of spiegeleisen, containing 10 per cent. of manganese. No. 11 is the final product, or hammered ingot of steel. Communicated by A. Willis, of the Landore Siemens' Steel Works, near Swansea, 1869.

3457. Bar of steel, produced direct from the ore by C. W. Siemens, 1866.

This bar has been tested by Kirkcaldy, and found to have a tensile strength of 57$\frac{1}{6}$ tons per square inch, and to elongate before breaking by 2·1 per cent. Communicated by C. W. Siemens.

Heaton's Process.

3458. Bars of wrought iron prepared by Heaton's process, one being twisted twice. Made at Langley Mill Iron Works, Nottingham.

This process consists in the addition of a charge of nitrate of soda in the bottom of a converter, separated by a cast-iron plate from the molten iron above. The plate melts, and reaction takes place, and the carbon in the cast iron is oxidised and removed. Steel or wrought iron result, according to the proportions used. *See* Bauerman, Metallurgy of Iron, p. 297. This bar has been tested by Brown & Co., and found to have a tensile strength of 44 tons to the square inch.

3459. Bar of steel made by Heaton's process at the Glendon Iron Works.

It is made from iron smelted from Northamptonshire ore, one-half Glendon and one-half Workington. It is fine grained and even.

Price and Nicholson's Process.

3460. Ingot of No. 2 steel from Swedish iron.

A moderately fine-grained square ingot, with numerous internal cavities. The process, which was patented in 1855, consists in melting refined pig-iron with suitable proportions of any kind of malleable or wrought iron so as to produce steel, the quality of which depends on the refining of the pig or "metal." The following proportions are given by Mr. Price. If equal quantities of a "metal" containing carbon 2·20, silicon ·20, sulphur ·03, and phosphorus ·30, and of bar iron containing no carbon, silicon ·15, sulphur ·007, and phosphorus 0·18 are taken, the resulting steel will contain carbon 1·1, silicon 0·17, sulphur 0·018, phosphorus 0·24.

3461. Square bar of steel tilted from ingot No. 2 above.

3462. Square bar of steel titled from ingot No. 2 at welding heat.

It is not very fine in the grain.

3463. Ingot of No. 3 steel from English iron and English bar-iron.

3464. Square bar of steel tilted from ingot No. 3 above.

3465. Chisel made of Price and Nicholson's steel.

This chisel has been tested on cast iron, out of which it has cut a cubic inch. The chisel has not been touched since, and its edge is seen to be scarcely affected at all. All these specimens illustrating Price and Nicholson's process have been communicated by Mr. Price in 1858.

Parry's Process.

3466. Carburised iron as it flows from the cupola. Made at Ebbw Vale Iron Works, 1865.

Parry's process was patented in 1861, and consists of melting scraps of wrought iron, which have been purified from phosphorus and sulphur by a previous puddling, and adding to them when melted sufficient coke or suitable pig-iron for the introduction of the required amount of carbon to produce either hard or soft steel. This specimen had 7 cwt. of pig-iron added, with a suitable amount of lime, to the ton of scrap iron.

3467. Irregular mass of Parry's steel flowing out of the cupola, 1865.

3468. Square cast bar of Parry's steel. Made at Ebbw Vale.

Communicated by George Parry, 1865. It is rather coarsely crystalline in fracture.

3469. Piece of rolled cast steel produced by Parry's process.

Made by carburising wrought-iron scraps in a melting cupola having twyers inclined downwards at an angle of about 30°. It has an exceedingly fine grain.

3470. Square bar of steel produced by Parry's process.

Wrought-iron rail ends have been fused in a cupola with coke by inclined twyers. The carbon in this sample is about the same as in "High Blown" refined metal. The puddled bar when chopped up and mixed with one-third its weight of this cast metal makes good cast steel. This has a fine grain.

Process for the refining of Iron for Tin Plates.

3471. Cinder first run off, from the charcoal finery at Ponty-Mister Tin Plate Works, 1859.

A porous sub-metallic mass.

3472. Cinder last run off from the charcoal finery at Ponty-Mister.

This is heavier and more compact. Both are of a dark blue black colour.

3473. Cinder obtained by hammering the ball or lump of iron. Obtained from the charcoal finery at Pont-y-Mister.

This is compact and black like the last. It has been melted.

3474. Refined metal taken out of the charcoal finery at Pont-y-Mister.

It has been hammered slightly with a hand hammer to show its malleability, but it is in a loosely aggregated state.

3475. Piece of stamp or ingot of iron obtained by hammering the refined iron from the charcoal finery at Pont-y-Mister.

3476. A mass of slag running out from the charcoal finery at Pont-y-Mister, and called "Fox tail."

It consists of two hollow cones with thick and irregular walls, fixed side by side.

3477. Pig of recast refined iron produced at the Pont-y-Mister Tin Plate Works.

It has the appearance of white iron, with a slightly scoriaceous surface and crystallisation radiating from the centre of the upper surface to the sides of the mould.

3478. "Black Plates" produced from the refined iron at Pont-y-Mister Tin Plate Works.

They have been annealed, as is seen by their tarnishes, and are now ready for the operation of tinning. *See* Percy's Metallurgy, Iron and Steel, p. 726.

Polish Methods of Iron and Steel making.

3479. Ore from which the steel is made.

It is an argillaceous ore impregnated with hæmatite.

3480. Piece of iron from which Polish steel was made at Lubartow in 1850.

Communicated by Douglas Evans.

3481. Bar of single shear steel made from the above iron.

3482. Bar of cast steel made from the above iron.

3483. Piece of tilted steel drawn from one of the above converted bars.

These are moderately fine in the grain.
They are all from Lubartow, Warsaw, and were communicated by Douglas Evans, 1851.

Indian Methods of Iron and Steel making.

3484. "Sal" charcoal as used in the manufacture of iron in Birbum, Babupoor.

Communicated by Mr. Blanford. It is small stick charcoal made from a cane called "*Shorea robusta*" or Sal. *See* Percy's Metallurgy, Iron and Steel, p. 257.

3485. The iron ore from which the following samples of iron are obtained at Nagore, Birbum, Bengal.

Communicated by Mr. Blanford. It is an earthy limonite in small pieces.

3486. Lump of iron produced in the Khasia hills, India.

It is produced from hæmatite, by an open forge, with double action bellows worked with the feet, as described by Sir J. D. Hooker. This lump has been nearly cut in two, and corresponds to the lumps figured by Sir J. D. Hooker. *See* Percy's Metallurgy, Iron and Steel, p. 264. Communicated by Sir J. D. Hooker.

3487. A similar lump of iron which has been partially hammered out into a flat blade.

From the same locality. Communicated by Sir J. D. Hooker.

3488. Rehammered iron as sold in the Bazaars of Nagore, Birbum, Bengal.

Communicated by Mr. Blanford.

3489. Mass of slag from an iron furnace at work in the jungle near Babupoor, Kandit, Kireyen, Birbum.

Communicated by Mr. Blanford. A thin black solid mass, with large cavities in the centre.

3490. Pieces of iron hammered out and one polished on one side.

These have no label, but appear to belong to the accompanying series and to be of Indian origin.

3491. Two pieces of iron melted in a crucible, possibly from the above.

Each shows radiating lines from the centre of the surface and a hollow in the centre. They have been covered when molten.

3492. Iron shot from native blast furnace. Slag used by native Shikarries from Birbum.

Communicated by W. T. Blanford. They are rusty on the surface, and are from the size of peas downwards.

3493. Piece of country made steel from Loomkoor in the Province of Madras.

Communicated by Dr. Hunter. It is a square bar of a very fine grained steel.

VARIOUS FORMS OF STEEL.

3494. Series of specimens of steel manufactured by Messrs. Frith and Sons at Sheffield in 1868.

The following are the samples: Two fragments of rough ingots, stamped "Thos. Frith & Sons" from the steel made by them for the inner tube of the Armstrong gun. A hollow bored gun barrel tube, originally solid, now bored by machinery, together with the spiral boring that came out of the hole. Square bar of shear steel; two bars of extra axe steel; best rounded edge bar for chisels; round bar of cast steel for tools; best octagonal bar for chisels; and three square bars of diamond cast steel.

3495. Bar of "Vicker's Special" steel.

Communicated by D. Watson, 1869, when the process of manufacture was a secret, the production of steel by Vicker's patent of 1839 being an earlier stage. *See* Percy's Metallurgy, Iron and Steel, p. 776.

3496. Bar of steel, marked D.P., worked up into a metal-turning tool.

3497. Bar of steel manufactured by Whitworth & Co., marked W.Y. 4, similarly worked up into a turning tool.

These two tools have been tested in comparison with each other, with an advantage to the latter of the two.

3498. Piece of a plate of Manby's spring steel, 1871.

Coarse in the grain and with a cavity in the centre.

3499. Part of an ingot of puddled steel made at the Ebbw Vale Iron Works, 1859.

Rather coarse in the grain and rough in fracture.

3500. Series of steel bar samples, communicated by Mr. Davis.

One marked "C" is HHH. steel. It is excessively fine in the fracture. One marked "D" is "watercracked steel" of only moderately fine fracture. A third is marked "MM." A fourth is "red short blister steel," which is cracked in the centre.

3501. Sample of red short steel marked "R," and of mild steel marked "A."

3502. Three bars of steel manufactured by the Titanic Steel and Iron Company, at the Forest Steel Works, Coleford, Gloucestershire.

They are excessively fine and conchoidal in the fracture.

3503. "Red metal steel" manufactured in 1876 by Whitworth & Co., and made up into a form suitable for testing the tensile strength by hydraulic pressure.

The first alteration in the test piece was observable under a tension of 25·87 tons. It elongated 29·93 per cent., and finally broke under a tension of 40·8 tons. The form of the fracture is very uniformly conical on the outside, though irregular in the centre.

3504. Specimens of steel bar supposed to contain titanium.

Communicated by Mr. May. All of them have a black tarnish on their fractured surfaces and an irregular hackly fracture. One marked "B" is spotted with minute specks. One marked "C" is a little coarser in the grain. The two others marked "K" and "S" are much finer grained.

3505. Steel chisel containing 1¼ per cent. of silicon. Made at Sheffield.

Communicated by J. Parry. It works and tempers well and behaves like ordinary cast steel.

3506. Series of specimens of steel from the Dannemora Steel Works, Sheffield, 1879.

Communicated by Messrs. Seebohm and Dieckstahl. They are as follows:—

A square bar labelled 0, of special Dannemora cast steel For turning and planing tools on hard material. It has a very fine silky conchoidal fracture.

A square bar labelled 1, of best warranted cast steel. Saw-file temper containing 1⅜ per cent. of carbon. Suitable for turning and planing tools, drills, &c. Requires great care in heating as it is very easily burnt. Has a silky fracture.

A round bar labelled 2, of best warranted cast steel. Turning tool temper containing 1¼ per cent. of carbon. The most useful temper for turning, planing, and slotting tools, drills, small cutters, and taps. Is not weldable. Has a granular fracture.

A square bar having the same label as the last. More silky in the lustre.

A round bar labelled 3. Best warranted cast steel. Punch temper containing 1⅛ per cent. of carbon. Suitable for mill picks, circular cutters, taps, rimers, small shear blades, large turning tools, and drills, punches and screwing dies. May be welded with great care. It has a moderately fine granular hackly fracture.

A hexagonal bar having the same label as the last. More silky in the fracture.

A flat bar with rounded sides labelled 4. Best warranted cast steel. Chisel temper containing 1 per cent. of carbon. Suitable for cold chisels, hot setts, large punches, large screwing dies, large taps, and miners' drills for granite. Will weld with care. Fine grained with hackly fracture.

A large square bar with bevelled edges labelled 5. Best warranted cast steel. Sett temper containing ⅞ per cent. of carbon. Suitable for cold setts, large hot setts, &c. Will weld without difficulty. Rather coarse grained with hackly fracture.

A large octagonal bar labelled 6. Best warranted cast steel. Die temper containing ¾ per cent. of carbon. Suitable for boiler cups and snaps, hammers, stamping and pressing dies. Welding steel for plane irons, miners' drills, &c. A moderately coarse granular fracture.

A round bar labelled 7. Best warranted cast steel. Specially manufactured with hard outside and mild centre for taps, rimers, &c. To be hardened at a low heat. Moderately coarse granular fracture in the centre.

3507. Square bar of cast steel, bent cold.

3508. A bent flat bar of "semi-steel" manufactured from grey coke pig-iron, at the Victoria Works, South Wales.

Communicated by C. May, 1858. Manufactured by the Bessemer and Mushet processes direct from the pig-iron.

3509. Samples of steel, manufactured by R. Mushet, 1866.

There are five pieces stamped 1, which are welding cast steel for edge tools; four pieces stamped 2, which are hard cast steel for turning tools or razors; five pieces stamped 3, which are cast steel for turning tools or taps, they are made of $\frac{1}{3}$ common Swedish iron and $\frac{2}{3}$ Cumberland hæmatite pig-iron. The larger piece marked 4, is chisel steel for fitters' chisels, that marked 5 is hard cast steel for turning tools or razors; that marked 6 is hard cast steel for turning tools or taps, and that marked 7 is best file steel for saw files and other superior kinds. It is from common Bessemer scrap titanised. All these samples are made "under the influence of titanium." They are all granular in fracture.

3510. Round bar of R. Mushet's gun-metal steel.

It has a granular hackly fracture.

3511. Two samples of R. Mushet's special steel for lathe and planing tools.

Manufactured in 1872 by the Titanic Steel and Iron Company, Forest Steel Works, Coleford, Gloucestershire. Communicated by R. Mushet. The fracture is microscopically fine, is conchoidal and has a silky lustre. This steel requires only to be cold hammered and not tempered in the ordinary way.

3512. Small round bar of R. Mushet's special tool-steel.

The sample is as used without hardening, 1873.

3513. Melted mass of carburetted cast iron. Made by Mushet the elder.

It is from the same iron ore from which the wootz steel is made and which yields 72 per cent. of this iron. Communicated by J. W. Lowry.

3514. Arsenical steel. Made and tested by F. W. Harbord and A. E. Tucker.

See their paper in the Proceedings of the Iron and Steel Institute for 1888. Twelve samples were prepared in all, of which this is No. 12 as containing the most arsenic. An alloy containing 15 per cent. of arsenic was prepared and melted in a large clay pot into which mild steel from a Bessemer converter was poured and mixed. The analysis of this sample gives, phosphorus 0·069 per cent.; manganese, 0·288; sulphur, 0·0348; carbon, 0·096; arsenic, 1·184: with this amount of arsenic the steel has rolled fairly well, but broke off short the first blow, both cold and hot. Tried with a machine, unquenched, it bore a stress of 24·9 tons to the square inch, it lengthened 1 in. in 8 in. and broke off short. Communicated by F. W. Harbord.

3515. Two samples of steel from the Lowmoor Iron Works.

Of large size and having a rough coarse fracture.

3516. "Homogeneous metal" made by Whitworth & Co.

Communicated by Sir J. Whitworth. It has been tested by gunpowder, but appears to have been in no way affected.

3517. Piece of "homogeneous metal."

Communicated by Mr. Whitworth. It is in the form of a section of a pipe which has been twisted into various shapes without showing any signs of breaking, so that it closely resembles indiarubber. *See* Percy's Metallurgy, Iron and Steel, p. 777.

Foreign made Steels.

3518. Shaped and polished piece of Krupp's steel. From the Exhibition of 1862.

It is broken across to show the fracture which is finely granular and hackly. Manufactured and fused at Essen.

3519. Small bar of steel of very silky fracture.

Stamped Z.B.F. $\frac{1}{5}$.

3520. Bar of Krupp's steel.

The outside of this bar has a silky fracture, in the inside it is coarser and granular.

3521. A fragment of Krupp's steel which had been part of the shaft of a marine axle.

Communicated by Mr. Lloyd, chief engineer of the Navy, 1862. This is very much more largely crystalline than was the surface of the shaft. *See* Percy's Metallurgy, Iron and Steel, p. 837.

3522. Square bar of Brescian steel. From the International Exhibition, 1862.

Communicated by the Italian Department. It has a finely granular fracture and has been forged at one end.

3523. Oblong bar of Brescian steel from the International Exhibition, 1862.

Similar to the last.

3524. Rough cast steel alloyed with tin.

From A. Krantz, of Berlin. It is made from a mixture of 7 lbs. of rough Dannemora cement steel and 7½ ounces of fine English tin. It is very fine in the grain.

3525. Two bars of steel, one square and one oblong, made from Dannemora iron.

From A. Krantz, of Berlin.

3526. Steel plate said to contain silver.

From A. Krantz, of Berlin. It is very finely granular, but on analysis by A. Dick, it is found to contain no silver.

COMPOSITE BARS, &c. OF SEPARATE LAYERS OF IRON AND STEEL.

3527. Triple plate of iron and steel of American manufacture used for plough-shares. 1886.

Communicated by D. Greig, of Fowler & Co.'s Steam Plough Works, Leeds. It consists of three layers of metal. The fracture of the outer ones is somewhat uneven, fine grained, and light grey; these are steel, and the fracture of the middle layer, which is thinner, is fibro-crystalline, and resembles malleable iron in appearance, and it is also laminated on the upper and lower surfaces, and very distinct from the outer layers. It is used for the shares of ploughs. *See* Percy's Address to the Iron and Steel Institute, 1886, p. 5.

3528. Composite plate of iron and steel in the rough state, as manufactured by Woodhouse and Rixson, Chantry Steel Works, Sheffield, 1887.

The two outer layers of steel are seen to have a finer grain than the inner one of iron; they are all about the same thickness. Communicated by F. Rixson.

3529. A composite plate of iron and steel polished, made at Sheffield for ploughs.

Communicated by F. Rixson. This is a curved plate, pointed at one end. In the fracture the coarseness of the grain of the iron and steel is well distinguished; the steel takes a higher polish, which is required for stiff soils to prevent the clods adhering to the plough-shares.

3530. Composite plates of iron and steel for plough mould boards, manufactured by Spear and Jackson, Etna Works, Sheffield, in 1884.

This consists of three layers of the same thickness, of which the wrought-iron layer is in the centre; it is stamped "Iron centre." The hard outside admits of a polish, the soft interior prevents the breaking. *See* Percy's Address to the Iron and Steel Institute, 1886, p. 22. Communicated by Spear and Jackson.

3531. Double plate, half iron, half steel, manufactured by Spear and Jackson, Etna Works, Sheffield.

The two metals are of equal thickness, and differ in their grain. It is stamped "Safe steel." Communicated by Spear and Jackson.

3532. Composite plate of iron and steel, manufactured by J. Braidshaw and Sons, Baltic Steel Works, Sheffield, 1886.

These are called soft-centred cast steel plough plates, specially manufactured for the Canadian market. They have been manufactured here since 1877. The plate is stamped "Conqueror." It has the centre iron layer thinner than either of the two steel layers, and it is also laminated as in the American sample, No. **3527.** Communicated by J. Braidshaw.

3533. Fragment cut from an armour plate made of iron and steel at the works of Sir J. Brown & Co., Sheffield, 1882.

Manufactured according to Ellis' patent. The outer two-fifths of steel has a rather coarse crystalline fracture, the inner three-fifths of iron is darker and strongly laminated parallel to the junction, which is marked by a band of coarser and brighter crystals. The total thickness of the plate is about 6½ inches. Communicated by J. D. Ellis.

3534. Corngreaves' patent safe compo-rivets, undrillable. Made at the Corngreaves Iron Works, near Birmingham, 1887.

Communicated by G. Allen. They consist of a number of small steel bars arranged regularly in the midst of iron, with which they are all welded together, forming a patchwork pattern when etched, but which is unobservable when they are polished. There are also three small samples composed of smaller bars.

3535. Bar of Corngreaves' patent compo-metal, bent and fractured.

This is specially made for the manufacture of chains. It is marked $\frac{262}{2}$, and has been heated to a bright cherry red and then plunged in cold water, so as to break it and show the highly fibrous fracture. This would stand a strain of about 30 tons per square inch, with 50 per cent. reduction of area and 23 per cent. elongation in 8 inches.

3536. Three links of a chain made of Corngreaves' patent compo, and hammered flat when cold.

These are stamped $\frac{803}{32}$, and contain ·13 per cent. of carbon. Their composite nature is not seen on the surface.

3537. Two burglar-proof safe plates of Corngreaves' patent compo.

One labelled $\frac{375}{33}$ is in its soft condition, and is easily drillable. It is not composed of square bars as the other specimens, but consists of an alternation of numerous plates of iron and steel, visible on the sides. The other, labelled $\frac{375}{33}$Q, is the same after hardening, in which condition it is undrillable. Seven plates are seen in this on the sides, which are seen also to be laminated on the fractured end.

3538. A burglar-proof rivet, of Corngreaves' patent compo.

It is bent and broken to show its structure, which consists of five square bars of steel, welded together in a matrix of iron. All these specimens were communicated by G. Allen, of the New British Iron Company, Corngreaves' Iron Works, near Birmingham.

3539. Bars of iron and steel, piled and drawn out by rolling.

The end has been etched with acid, so as to show the steel by the blackness thereby induced. Communicated by K. Blackwell many years previous to 1880. The different rods are arranged in section like the squares on a chess board.

IRREGULARITIES IN STEEL.

3540. Piece of steel plate on which a large blister rose after it came through the rolls, at the Locomotive Works, Crewe.

Communicated by F. W. Webb. The cavity has not been opened, and whatever gas may cause it may still be enclosed within the steel.

3541. Piece of blister-steel with two large hollow blisters.

Produced in the ordinary process of the conversion of bar iron into steel. The fracture is coarsely crystalline, and shows a certain amount of lamination. *See* Percy's Metallurgy, Iron and Steel, p. 772.

3542. Piece of blister-steel with one large hollow blister extending on both sides.

From Messrs. Hunt's Works, the Brades, Birmingham, 1846. The bar has a coarse crystalline fracture, and is markedly laminated at the end. The blister rises over a surface of about 2 inches by 1 inch. *See* Percy Journal of the Iron and Steel Institute, 1877, No. 2.

3543. The interior of a blister broken open.

Communicated by Mr. Ibbetson, Sheffield, 1878. The fracture is very white, but the inside of the blister, which is thrown into folds, is lined with a blue-black coating resembling iron sulphide.

3544. Blister-steel which has been over-fired in the converting furnace.

Portions of the bars of blister-steel are converted into grey cast iron, and these melt out from the under side and drop down on to the bars below. The amount of carbon in the melted and unmelted portions respectively have been ascertained to be 2·263 and 1·318 per cent. The specimens are eroded into hollows from this cause. Communicated by W. Baker, Sheffield, 1872.

3545. Steel showing irregularities in its hardness.

The specimens are cut out of discs turned off the end of a block about 13 inches diameter and 10 feet long, made of steel cast out of small pots into an iron mould and drawn out under the steam hammer. The hard spots have turned the tool in the slotting, but they are aggregated small spots, seen by filing. Communicated by G. W. Rendel, Elswick Works, Newcastle-on-Tyne, 1872.

3546. Experimental piece of steel, treated for the purpose of testing the cause of blisters.

The theory of Dr. Percy is that they are caused by the accidental, though unavoidable, presence of portions of slag in the mass which has been puddled but never thoroughly melted (*see* Metallurgy, Iron and Steel, p. 772). If this were so, then a thoroughly melted bar of malleable iron which was converted by the process of cementation should show no blisters. Swedish bar iron has been melted by Mr. Frith, of Norfolk Works, Sheffield, and cast into a flat ingot. This has been converted, and the fracture of the specimen (about 6 inches long by 3 inches broad and $\frac{7}{12}$ inches thick) is quite characteristic of steel, but there is no sign of a blister. *See* Percy, "On the causes of Blisters in Blister-steel" in the Journal of the Iron and Steel Institute, 1877, No. 2.

3547. Piece of highly carburised steel. From Messrs. Frith's Iron Works, Sheffield, 1876.

It is very coarsely crystalline in fracture, yellowish in tint, and show numerous small blister cavities within and without.

IRON AND STEEL SPECIALLY TREATED.

3548. Specimen of steel which has been bent and shows lamination.

Obtained at the works of Messrs. Cammell & Co., Sheffield, 1882. It is part of an ingot which has been hammered and rolled cold, such as are used for making ship plates. This has been bent completely double, and then separated again. Its fracture and one side show well-marked lamination.

3549. Series of specimens of steel melted with and without manganese in order to ascertain the result of the addition, 1864.

There are first two fragments of the original bar steel, labelled B. and E. V., with blisters, which have been used in the melting, a fragment of a square ingot, with bevelled edges, which has been melted without manganese, and a fragment of a similar ingot of the same size melted with manganese as usually at that time practised in Sheffield. Two larger sized tilted bars, broken to show the fracture, one from the ingot with manganese and the other from the ingot without. Two smaller bars from the respective ingots, and some small fragments of these variously treated, *i.e.*, one has been heated, softened by heating, another has been heated and left to cool, and a third heated and quenched in water. The two kinds have been analysed by A. Dick and give—

	Without manganese added.	With manganese added.
Iron	99·05	99·09
Manganese	0·03	0·10
Silicon	0·24	0·24
Sulphur	0·05	0·07

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Phosphorus -	0·02	0·02
Aluminium -	0·12	0·01
	99·51	99.53

The carbon has not been estimated. *See* Percy's Metallurgy, Iron and Steel, p. 846.

3550. A series of specimens treated so as to show the effects on the fracture of steel of various ways of heating and cooling.

These experiments were carried out by Col. H. Dyer, R.A., and the results communicated by him. No. 1 are samples of the forgings of steel which were used in the other experiments; the fracture is finely granular. No. 2 have been heated in a cast-iron pan with sand to below the melting point of brass, which was secured by placing a pan with a piece of brass in the furnace along with the steel, and left to cool in the furnace all night, then covered in charcoal and swarf and left till cold; the fracture is granular in the centre, but coarser round the circumference. No. 3 have been heated in smithy scale to a bright red heat, and left to cool in the furnace all night; the fracture is much coarser. No. 4 have been heated in hæmatite ore to the melting point of copper. This is ascertained by placing a piece of copper on the hearth beside the steel, and when the copper melts the heat of the furnace is checked and made to cool as slowly as possible; the steel casting being left in it. The fracture is moderately coarse. No. 5 have been heated in equal parts of hæmatite ore and sand to the melting point of copper, and left in the furnace all night to cool. Fracture moderately coarse, with a finer grained patch in the centre. No. 6 have been heated in iron swarf and charcoal to the melting point of brass, left to cool all night in the furnace, reheated to cherry red, cooled in water, and reheated to the melting point of brass (ascertained as in the case of copper), and left again in the furnace all night to cool. Fracture rather fine grained. No. 7 have been heated under the same conditions as No. 6, but have not been hardened. The fracture is coarser round the circumference and finer in the centre. No. 8 have been heated in lime to bright redness for 40 minutes in the furnace. The fracture is finely granular throughout. No. 9 have been heated in steel swarf and charcoal to bright redness 40 minutes in the furnace. The fracture is very fine grained. No. 10 have been heated in charcoal to the melting point of copper, and left in the furnace all night to cool. The fracture has a coarse ring round the circumference. No. 11 have been heated in iron swarf and charcoal to the melting point of copper, and left in the furnace all night to cool. The fracture is moderately granular. No. 12 have been heated in charcoal and steel swarf to the melting point of brass, and left in the furnace all night to cool. The fracture is pretty coarse. The points of all the specimens have been hardened in water.

3551. Steel coated with magnetic oxide of iron.

By Bowers and Barffs' process, which consists of submitting the articles to be coated to super-heated steam, or to carbonic acid, or to petroleum vapour in a cast or wrought-iron chamber heated externally. By this means the surface is oxidized to a limited amount, producing a protective coat of magnetic oxide. *See* the various Patents, No. 862 of

1876, No. 2051 of 1877, No. 1280 of 1878, No. 3811 of 1880, and No. 3304 of 1881. Communicated by Mr. George Bower.

3552. Wrought-iron plate coated with magnetic oxide of iron by Bowers and Barffs' process, 1881.

Communicated by Mr. Geo. Bower. *See* No. **3551.**

3553. Wrought-iron pipe coated with oxide of iron by Bowers and Barffs' process, 1881.

In this case the oxide is said to be the ferric and not the magnetic oxide. It has a reddish tinge. Communicated by Mr. Geo. Bower. *See* No. **3551.**

3554. Large wrought-iron tube coated with magnetic oxide of iron by combination of Bower and Barffs' processes.

Communicated by Mr. Geo. Bower. *See* No. **3551.**

SPECIAL ADAPTATIONS OF IRON AND STEEL TO VARIOUS USES.

3555. Three forms of manufacture of gun barrel.

The first is a simple hollow tube. In the second a single bar is bent into a spiral, and the several adjacent coils are welded together into a single tube forming the barrel. In the third, three smaller bars are twisted into screws, and all welded together into a single flat bar, which is then itself twisted into a spiral to form the gun barrel as before.

3556. Hollow hemisphere of mild steel. Manufactured at the Landore Siemens' Steel Company, at Landore, South Wales, and subjected to the dish-test cold, 1886.

It consists of a piece of $\frac{3}{8}$ boiler plate, dished cold. The tensile strain of this metal is 26·5 tons per square inch, and the elongation in 8 inches 28·5 per cent.

3557. Three bars of mild steel, tied cold, at the Steel Company of Scotland's Works, Glasgow. Manufactured by Siemens' process, 1885.

The largest is about 1 inch in diameter; the others are about $\frac{1}{2}$ inch and $\frac{5}{16}$. They are tied into various knots and varnished. The following data have been determined in regard to the charge from which the material was taken. It contained: carbon, ·17 per cent.; sulphur, ·05; phosphorus, ·05; manganese, ·47; and silicon, a trace. The steel has a tensile strength of 28·7 tons per square inch, an elongation of 30 per cent. in 8 inches, and an elastic limit of 14·7 tons per square inch. Communicated by J. Riley.

3558. Plate of mild steel bent three times on itself, at the Steel Company of Scotland's Works, Glasgow, 1885. By Siemens' process.

The steel of which this is made contains, carbon, 18 per cent.; sulphur, ·03; phosphorus, ·04; manganese, ·5; and silicon, a trace. Its tensile strength is 29 tons per square inch, the elongation was 24 per cent. in 8 inches, and the elastic limit is 15 tons per square inch. Communicated by J. Riley.

3559. Bessemer mild steel boiler-plate, bent cold, and drilled cold from a $\frac{5}{8}$ in. punched hole. Manufactured at the Locomotive Department, Crewe Works, 1877.

Communicated by F. W. Webb. It is one of over 20,000 then made, proving how very uniform the material is.

3560. Three Bessemer mild steel plates, made for boiler and other purposes, two of which have been tested to their breaking point, at the Crewe Works.

Communicated by F. W. Webb. This steel has a tensile strength of between 28 to 30 tons per square inch, and the elongation before fracture is shown by these specimens. The whole bars have elongated by comparison with the untested example about 1 inch. The breadth of the narrower part before testing is 2 inches. After separation is reduced by about 20 per cent.

3561. Four Bessemer mild steel angle irons, bent and folded cold in various ways, at the Crewe Works.

Communicated by F. W. Webb. They are portions of a steamer built for the London and North-western Railway Company by Messrs. Laird, of Glasgow, the material being made at Crewe. Not one of them shows the slightest sign of breaking.

3562. Bessemer mild steel rivet bars, bent cold at the Crewe Works.

Communicated by F. W. Webb, 1877.

3563. Rough turning from Bessemer steel crank axles, for locomotives.

From the Crewe Works, showing the homogeneity of the material. Communicated by F. W. Webb.

3564. Finished turnings from Bessemer steel crank axles.

At the Crewe works. Communicated by F. W. Webb.

3565. Broad smooth steel turning, from the Woolwich Arsenal.

Not tarnished by the moist air.

3566. Scale from rolling steel rail at Dowlais, South Wales.

A thin sheet of dark sub-crystalline compound with cracked pyramidal elevations on the convex side.

3567. Seven specimens of iron for armour plates. Analysed for the Special Committee on Iron in 1863.

They are stamped B 1, B 2, B 3, B 4, B 9, B 31, and P.

3568. Samples of armour plates which have been broken by shots.

They are labelled W. and P. and show on the fracture a coarse crystalline structure with marked signs of lamination, brought about by the presence of more or less slag, which has not been eliminated.

3569. A thick iron armour plate, which has been tested to the breaking point by Cammell & Co. of Sheffield.

It shows a strongly marked fibrous structure parallel to the surface of the plate, with here and there brilliant patches, like the cleavage of surfaces of iron phosphide.

3570. Portion of Rodman's shot, fired at Shoeburyness.

Rodman was the American who cast the 70-ton gun in the Civil war in the United States. This has been analysed by W. J. Ward in 1868, and is found to contain graphite 2·83, combined carbon 0·34, silicon 0·82, sulphur 0·04, phosphorus 0·25, manganese 0·45 per cent. with a trace of copper.

3571. Portion of the Rodman shot, fired at Shoeburyness.

Of granular grey cast iron, similar to that analysed.

3572. Piece of Dr. David Price's 15-inch shot, fired the 31st of March 1869.

Communicated by Dr. Price. It is mottled cast iron, of not much purity.

3573. Piece of iron armour plate, smashed by a shot at Shoeburyness.

It shows a highly laminated structure.

3574. Grey cast iron shot, broken up by firing against an iron target at Shoeburyness.

There are no signs of lamination in the fracture, which is finely crystalline granular to the surface.

3575. Piece of armour plate made at Portsmouth Dockyard and found to be bad.

Communicated by Captain Drummond. It is very laminated and coarse, though thin, and shows much impurity.

3576. Specimen of iron broken by a shot at Shoeburyness, 1866.

Seen on one side the specimen has a beautifully silky fibrous fracture; on the other side it is somewhat laminated, but highly crystalline; at the cross section at the end the fibrous part breaks off in black patches, and the rest shows a crystalline fracture. It thus appears that in the same iron it is different material, that has a fibrous or crystalline fracture.

3577. Two rivets destroyed by shot at Shoeburyness.

One of these is broken across and shows its crystalline fracture, the other, originally identical in character, is sheared, and the surface of separation smoothed by some particles of iron being drawn along over others.

3578. Pointed end of an Armstrong shot which struck point blank an iron target at Shoeburyness in 1863.

The shot was of grey pig-iron. This portion of it now consists of two conical masses, the smaller on one side, with the other one fitting over it, but turned out at the edges, like a piece of butter. Both one and the other are slickensided from the summit. This specimen demonstrates that under suitable circumstances solid pig-iron may be made to *flow*. This, however, is not generally the result. Much heat is usually developed by the impact, and a large quantity of the iron may be reduced to powder. The appearance of flame at the point of contact may be due to the fuming up of the highly heated iron dust thus produced.

3579. Piece of French screw torn out by a shot at Pole's Target, Shoeburyness, 1864.

It shows for the most part a fibrous fracture.

3580. Piece of Armstrong gun breech-piece broken across.

This shows a laminated crystalline fracture with bands of earthy matter running across it. Communicated by General Lefroy, of the Arsenal, Woolwich. A larger piece of the same breech is in the Royal Artillery Institution, Woolwich.

3581. Wrought-iron armour plate broken by a cannon ball at Shoeburyness.

It shows a highly crystalline fracture, the length of the crystals being parallel to the surface, and they are mixed with much slag which is retained in welding one plate to another, in the usual process of manufacture.

3582. Iron from a piece of plate knocked out by a shot in Prussia in 1861.

They are fragments showing a fibrous structure, perpendicular to the surfaces of the plate.

3583. Chilled cast-iron shot fired against an iron target at Shoeburyness and broken.

It shows a radiating crystallisation passing to the surface as in white iron, but its colour is rather mottled.

3584. Fragment of armour plate tested at Shoeburyness in 1868, and which completely failed.

It was made from an Armstrong coil, and split open by cutting, and then flatted out at a strong heat. The fracture is highly crystalline and the plate is found to consist of oblique bands. Some of these are marked by a transverse fibration, and some by large plate-like crystals. It practically consists of a number of parallel bars welded together, and by re-heating the texture of the iron would become more largely crystalline. The thickness of the plate was 8 inches. Communicated by Gen. Lefroy.

3585. Part of a fly-wheel of an engine. From Dallam Iron Works, Warrington.

Communicated by W. Flight. It shows a cavity into which octahedral crystals, single and combined, of iron project.

3586. Specimens of $\frac{9}{16}$ in. bolt iron, before and after re melting, to show the effect on the fracture.

The original bolt shows a finely fibrous fracture. A portion of the same has been melted, and the button when broken shows a very coarse crystalline and flaky fracture. Communicated by E. Riley.

3587. Section of a rail of Bessemer steel tested for the Great Northern Railway Company by Messrs. Cammell, at the Cyclops Steel and Iron Works, Sheffield.

The weight of the rail is 80 lbs. per yard, and it was tested by a weight of 1 ton falling on it from different heights, the distance of the points of support being 3 ft. When dropped from the height of 15 ft. the ton weight caused a deflection of $1\frac{3}{8}$ in. At the second blow, with a fall of 20 ft., the rail was deflected $2\frac{7}{8}$ in. At the third, with a fall of 25 ft., $4\frac{7}{8}$ in. The bar was then reversed so that the deflected point was upwards. At the first blow of the ton falling from 15 ft. it deflected $3\frac{1}{2}$ in. At the second, with a fall of 25 ft., it broke.

3588. Collection of samples of rails made for the Great Railway Company of Russia at the works of Terre Noire, Lyons, 1875.

Communicated by the Terre Noire Iron Company. One is labelled as "Martin," another as "Bessemer," a third is laminated on the surface, and the other two are broken. Compare Percy's Metallurgy, Iron and Steel, p. 724.

3589. A section of one of these steel rails which have been tested by Chas. Cammell & Co., Sheffield, 1876.

The chemical analysis shows the rail to have a large excess of phosphorus. There is 0·15 per cent. combined carbon, 0·06 per cent. sulphur, 0·26 per cent. phosphorus, and 0·77 per cent. manganese, with a trace of silicon. The rail sent to be tested was cut into three portions, each 4 ft. 6 in. long. These were rested on two supports with circular ends of 3 in. radius, the distance between the points of contact being in each case 3 ft. 8 in. Three trials were made till the portions broke. A weight (of similar form to the support) of 2,240 lbs. falling from a height of 15 ft. 4 in. broke it immediately. A weight of 1,232 lbs. falling from 6 ft. deflected it $\frac{7}{8}$ in., and falling from 8 ft. broke it. A weight of 605 lbs. falling from 3 ft. bent the third piece $\frac{3}{16}$ in., and falling from 4 ft. 6 in. bent it $\frac{7}{16}$ in., and from 6 ft. broke it. These results for a rail weighing $66\frac{3}{4}$ lbs. per yard are not considered satisfactory. The fracture is remarkable as showing here and there brilliant white spots.

3590. Steel worked into the form of a tyre in section. Produced at the Lowmoor Iron Works, 1868.

It has a moderately coarse crystalline fracture.

3591. Polished model section of a rail as used on the Belgian State Railways, 1887.

Produced by the "Société Cockerell," at Seraing, Belgium. Communicated by C. P. Sandberg.

3592. Section of spoke of a cast steel wheel. Made at Monk Bridge, Leeds.

Tested in 1885. It has a coarse crystalline fracture.

3593. Plate of iron which has been cast and which has round holes in it, punched cold, by the Carron Company, Falkirk, N.B.

The plate contains an ornament in the centre consisting of a basket of flowers, and a frame which has been cast, but yet it has stood punching cold without breaking. Communicated by Mr. H. Blain, 1886.

3594. Tin plate made from No. 3 steel, equal to charcoal plate.

The No. 3 steel was made at Blaenavon in a 3-cwt. Bessemer converter from pig-iron, containing 1·4 per cent. of phosphorus. *See* the Thomas-Gilchrist process, Nos. **3440** *et seq.*

3595. Piece of sheet steel after cutting out the blanks for steel pen making.

From W. Jessops & Co.'s Works, Brightside, Sheffield, 1885. It is returned from Birmingham to be remelted.

3596. Steel pens tipped with brass. Made at Birmingham, 1854.

Communicated by Mr. Pershouse.

3597. Steel pens made from steel which has been smelted direct from the ore.

They are stamped "King of Denmark."

3598. Cast iron used for plough-shares. From Fowler & Co.'s Steam Plough Works, Leeds, 1885.

It is cast in chill from Weardale pig. The fracture is very finely granular, and shows grey iron in all but a narrow rim of white iron crystallising perpendicularly to the surface.

3599. Cast-iron screws annealed in coke dust.

Made of Blaenavon iron at Mr. Walker's Works, Wolverhampton.

3600. Cast-iron screws made from Lorn iron, Ulverstone.

They have been annealed for 48 hours in hæmatite, and have thereby lost weight. The iron will not mix with Blaenavon iron. Communicated by Mr. Walker.

3601. Iron nails in the shape of ornamental brass nails, ready to be electro-plated.

Communicated by Mr. Fearn, electro-plater, Birmingham.

3602. Electrotype iron, produced in the process of "Aciérage" at Messrs. Rollason's Works, Sheffield.

Communicated by H. Bradbury. This is the deposit of 48 hours, and shows the pattern of a nature printed fern-frond.

3603. Piece of the iron column at Delhi.

This column is between 40 ft. and 50 ft. in total length, and 26 ft. from the ground to the top, and 5 ft. in circumference. It is made of wrought iron, as shown by the small accompanying bar forged out of a piece. It does not sensibly harden by melting and cooling rapidly. Communicated by Lieutenant Cole.

3604. Iron coin issued by the Chinese Emperor in 1857. From the mint of Tuh Chow Foo, capital of the Province of Fuh Kien.

It is a round coin with a square hole in the centre. It is black on the surface and badly cast. It was ill received by the people, and created great disturbance. Communicated by S. Birch, 1858.

3605. Iron tray coated with tortoise-shell lacquer. Made at Taganrog in Russia in 1865.

Communicated by John Hughes, manager of the works.

3606. Seven samples of iron and steel wire which have been subjected to tests for tenacity by O. Schafer, 1886.

No. 1 is a steel wire, with a breaking strain of about 120 tons per square inch. No. 2 is steel, whose breaking strain is 70 tons. No. 3 is steel, with a breaking strain of 120 tons. This is much thicker than No. 1, and as wires of the same quality have a less than proportionate breaking strain, as their diameter is greater, this must be of a different quality. No. 4 is of homogeneous metal, or soft iron, with a breaking strain of 30 tons per square inch. Nos. 5, 6, and 7 are iron wires of less tenacity.

3607. Collection of short lengths of fine steel wires which have been tested for tenacity, which is very high.

They are tinned on the surface, and have been made the subject of elaborate experiments. A, B, C, D, and E, are all from the same rope.

Pieces from outside end of Coil. *Pieces from inside end of Coil.*

Length tested=10 *inches.*

A.

Diam. in Inches.	Per-centage of Elongation before Breaking.	Breaking Strain.		Diam. in Inches.	Per-centage of Elongation before Breaking.	Breaking Strain.	
		Actual in Lbs.	Calculated per Square Inch in Tons.			Actual in Lbs.	Calculated per Square Inch in Tons.
·0195	1·4	113	168·9	·0190	1·0	114	179·5
·0195	1·0	101	151·0	·0195	1·0	102	152·5
·0195	1·0	101	151·0	·0185	1·2	97	161·1
·0190	1·0	103	162·2	·0200	1·2	113	160·6
·0200	1·0	103	146·4	·0195	1·0	97	145·0
·0200	1·2	104	147·8	·0195	1·2	102	152·5

B. **C.**

·0190	1·0	103	162·2	·0191	1·3	111	173·0
·0190	0·8	95	149·6	·0190	1·0	90	141·7
·0180	1·2	110	193·0	·0188	1·0	93	149·6
·0190	1·0	90	141·7	·0191	1·2	87	135·6
·0190	1·0	103	162·2	·0190	1·4	105	165·3
·0185	1·0	100	166·1	·0186	1·3	104	170·9

D. **E.**

·0191	1·2	100	155·8	·0191	1·1	94	146·5
·0192	1·3	110	169·6	·0189	1·3	101	160·7
·0192	1·4	110	169·6	·0190	1·0	95	149·6
·0192	1·1	95	146·5	·0188	1·4	111	178·5
·0190	1·0	107	168·5	·0189	1·3	104	165·5
·0193	1·0	93	141·9	—	—	—	—

3608. Coil of thicker steel wire, tested for tensile strength which is very high.

This has also been tinned over, and has yielded the following results:—

Tests of bright Steel Wire.—Length tested = 10 *inches.*

Diam. in Inches.	Per-centage of Elongation before Breaking.	Breaking Strain.	
		Actual in Lbs.	Calculated in Tons per Square Inch.
·030	2·5	269	169·9
·030	2·6	269	169·9
·030	2·8	264	166·7
·030	2·5	261	164·8

3609. Series of pianoforte steel wires, made according to Horsfall's patent.

This patent was granted in 1854, and its essence consists in finally drawing the wire tempered at about dark blue, which is the melting point of lead, into which the steel wire is immersed. They are labelled Horsfall and Webster, Birmingham. Improved Vienna, No. 20, 103 grains; No. 14, 60 grains. One of these wires having a specific gravity of 7·85 is said to have a tensile strength of 100–120 tons per square inch. Communicated by Dr. Pole. *See* Percy's Metallurgy, Iron and Steel, p. 854.

3610. "Fowler's Special" steel wire.

Made by Rollason and Slater, Birmingham. Communicated by J. Fowler. In comparison with other wires this has the greatest breaking strain. Thus the crucible steel wire breaks with 40–60 tons per square inch. Patent steel wire with 80–90 tons. Plough quality ditto with 100–110 tons. Improved plough quality with 110–120 tons. This requires 150 tons per square inch to break it.

3611. Wittenstrom's "Mitis" castings.

Communicated by C. Wittenstrom of Stockholm, 1886. They consist of a double casting of a kind of bracket in the rough with adherent sand and some fragments to show its uniform and unblistered fracture. One of them is bent without breaking.

3612. Nordenfelt "Mitis" wrought-iron castings. Manufactured in Sweden.

Communicated by E. A. Cowper. There is a treble casting of a screw key, one of which is bent into a curve without breaking; a screw key bent double three times, and another with one side polished; and a shaped casting, one side of which is bent without breaking. These are from the same works as the last, Wittenstrom being the inventor. The process is the subject of a patent No. 8269, 1885. The principal feature is the addition of a small proportion of aluminium, which enables the gases to escape, and produces a uniform casting. *See* Percy's Presidential address to the Iron and Steel Institute, 1886.

3613. A hair-brush made of malleable cast iron, by Wittenstrom's method of "Mitis" castings.

The iron when treated in this way, *i.e.*, by the addition of aluminium, is made to flow like milk, and runs down even with the small cavities represented by the wires. Communicated by J. Orum, 1887. One of the cones is bent in two, to show its flexibility.

Watchmakers' Steel.

3614. Flat-spring wire for ordinary English watch.

3615. Two samples of hair-spring wire for marine chronometers.

Both are white, polished, and flat, but one is broader than the other.

3616. Marine chronometer spring.

This is the broader wire worked into a cylindrical spiral and tempered to a brilliant blue.

3617. Hair-spring for a small watch.

An extremely small flat wire, wound into a flat spiral to which the flatness of the wire is perpendicular, and tempered to a brilliant blue.

3618. Main-spring of a watch of best construction.

A broad band, wound into a flat spiral, and tempered to a purplish blue.

3619. Main-spring of an American keyless watch which broke suddenly.

It is tempered brown and is broken about 1 inch from the centre.

3620. Spring of a lever watch made at Clerkenwell similar to those made for the Arctic Expedition, and which broke suddenly.

It is tempered purplish brown and broke about 3½ inches from the centre.

3621. Main-spring of a watch smaller than a threepenny piece.

The exterior diameter of the compressed spring is about $\frac{1}{4}$ inch, and the interior $\frac{1}{6}$ inch, in the intervening $\frac{1}{24}$ inch on each side are 8 coils. They are tempered a slightly purplish blue, except the inner one which gradually changes to white.

3622. Broken main-spring from a very large time-piece.

A band $\frac{3}{4}$ inch broad and tempered blue and purple, broken in several places.

3623. Minute steel parts of a watch.

A horizontal escape wheel and cylinder and three small jewel setting springs and a screw.

3624. Chainwork for an English watch.

Made by women at Christchurch, Hants. These chains are composed of flat links, swollen transversely at each end, alternate links coming in contact and each rotating on a pivot passing through an internal link at the points where there are swellings of the external link.

3625. Series of watchmakers' small tools.

They consist of one oblong file, double cut on the flat side and single cut on one narrow side, one square and one round double cut rat-tailed file, one minute single cut flat file, four half round files double-cut on the flat side only, and one flat bevelled file single cut on all the bevelled edges. They are all of foreign manufacture bearing the name of Proutat, Brizard, and Baumer.

3626. Watch pivot broach, or rimer.

The smallest English one made. All the above specimens of steel used in the manufacture of watches (except No. **3619**), were obtained from Mr. Brock of George Street, Dorset Square.

3627. Penknife with blades made of Wootz steel.

The blades are stamped with the name "John Sellers and Son, Improved." Wootz is the name of Indian steel made by carburising compact iron. Its analysis is given in Percy's Metallurgy, Iron and Steel, p. 775.

3628. Penknife with blades made of Mushet's titanium steel.

It is said also to contain tungsten. *See* No. **3511.**

3629. Stirling's patent bell-metal alloy, cast into a bell.

This is iron alloyed with a small proportion of tin. From the Exhibition of 1851. *See* Percy's Metallurgy, Iron and Steel, p. 162.

3630. Bell made of an alloy composed of 95 parts of white cast iron with 5 parts of antimony.

The bell has two irregular holes on the top, but the tone is good.

3631. Bell made of an alloy composed of 95 parts of white cast iron with 5 parts of tin.

This has several irregular holes on the sides, and the tone is not very good. *See* Percy's Metallurgy, Iron and Steel, p. 162.

3632. Guard of Japanese sword hilt, made of iron overlaid with a pattern in gold.

This has the appearance of being inlaid with gold, but it is not inlaid in the ordinary sense. The surface of the iron where the gold pattern is fixed is very finely cross hatched. Some form of stencil plate is apparently then used, which limits the gold to the pattern. Where it comes in contact with the iron it is pressed into the cross hatchings by which it is held in firm adherence. The pattern represents some imaginary bird in a bower.

DEFECTS IN IRON AND STEEL.

3633. Gun coil from Woolwich Arsenal showing the effects of the iron being "red short."

The coarse fibres of the iron run parallel to the circumference of the coil, and on the outside they have parted in several places, making the sides jagged with chasms.

3634. Blistered boiler plate from the ventilation department, Houses of Parliament, 1881.

The inner part has a great cavity, and is separated along the base of it from the outer part of the plate. It was found that the tube in this boiler had been made at another works, and not at Lowmoor as according to specification.

3635. Piece of a boiler plate which gave way along an arc of fracture 12 inches long.

The rusty side of the specimen is the boundary of the crack. The fracture on the other side is silky-crystalline, and shows no signs of lamination.

3636. Part of a spoke of a cast-iron spoked car-wheel, which shows a hollow cavity in its interior.

Made at the London Road Foundry, Edinburgh, 1881. Communicated by H. Louis. This is not a blow-hole or other ordinary defect, but depends on the metal, contraction occuring during solidification and thus causing the hollow. Often the interior of the cavity shows a more or less distinct crystallisation, and this seems to assist in the formation of cavities. The approximate composition of the iron is combined carbon 0·6, graphite 2·3 to 2·6, silicon 0·6 to 0·7, phosphorus 0·36, sulphur 0·08, manganese 0·4.

3637. Piece of the cast iron beam which broke at the Hartley Colliery accident, January 1862.

The tensile strength was determined to be 473 lbs. per square inch. The iron contains 2·68 per cent. of silicon, 1·11 per cent. of phosphorus, and 0·16 per cent. of sulphur. Communicated by Mr. Dunn.

3638. Piece of Bessemer steel, formed into an angle bar from the lower edge of the keel of the ship "Magdala," 1868, which broke on falling to the ground from the height of a few feet.

Communicated by Sir Spencer Robinson. It has been analysed by W. J. Ward.

Silicon - - - -	0·212
Manganese - - -	0·382
Phosphorus - - - -	0·067
Sulphur - - - -	0·067
Iron - - - - -	99·112
Carbon (by difference - -	0·160
	100·000

3639. "Black plates" in the tinned plate process, which separate into two and rise into blisters.

From the Cumbrian Iron Works, Newport, Mon. Communicated by R. S. Roper, 1866. About 2½ cwt. of scrap taken from the blacksmith's shop was used up in the charcoal refiner's fire, and thus converted into stamp iron, mixed with the other iron, and made into several bars, and finally rolled into black plates with these blisters.

3640. Tin plates in which the tin leaves the surface of the iron and breaks up with a jagged edge.

Due probably to the deposit on the surface of the plate of some slag which has not been sufficiently eliminated from the iron before tinning. Communicated by J. Williams. Pentyrch Forge, Cardiff, 1868.

WEARING AND DECAY OF IRON.

3641. Tie rod of wrought iron taken from a cistern in Somerset House after 16 years use.

The original diameter was ¾ inch, and the service of water was intermittent. The tie rod is irregularly worn away, and shows longitudinal lines and knots like a stem of a tree, and in one part is reduced to about ⅓ inch in diameter.

3642. Pipe coated over with a crust of ferric oxide.

No information accompanies this pipe. It is about 18 in. long and ½ inch diameter. Internally it is quite smooth and apparently unworn, but externally it is thickened up to 1¼ inch diameter by a coat of ferric oxide (?), which is laminated and also split into longitudinal bands.

3643. Pipe for condensed steam from a battery at the Houses of Parliament, 1865.

It is choked up to nearly the centre by a series of concentric deposits of rust, which are additions to its substance and not derived from it, the pipe itself being almost entirely unacted on.

3644. Two halves of an iron steam pipe taken from the West Front smoke shaft in the Houses of Parliament after 3½ years' use in 1865.

This is the return pipe for the condensed water. It is about 1¼ inch in diameter. One half is very little altered, having only a deposit of rust; the other half is deeply corroded and perforated in three separate spots, and thickened with rust elsewhere. These spots lie along the line where the tube has been joined, the joint having been cemented by a second metal (solder?).

3645. Scale from the interior of an iron vessel.

The thickness of plate which has decayed, according to the percentage (63·53) of iron in the scale is 0·079 inch. The scale contains ferric oxide 84·24, ferrous oxide 5·87, water 7·80, and the outer surface contained oxide of lead in sensible quantities, and traces of chlorine and sulphuric acid.

3646. Broken boiler plates and bolts. No history.

The plate has broken into laminæ and also torn where the bolts were inserted.

3647. Stud belonging to a pump bucket, from Orange Street Waterworks, after three years' use.

It was coated with Dr. Angus Smith's preparation before use, and has been continuously immersed in water during its three years' use. It is not very deeply corroded, but sufficiently so to bring out its laminated structure.

3648. Old and new back nut in the Range Boiler, Sealer's Room, West Front, Houses of Parliament.

The old one had been in use about 12 months. The outside has rusted away to about one-half its original thickness.

3649. Round wrought-iron bar which had been for eight or nine years at the top of the front of a kitchen range.

Communicated by J. H. Marshall, Edgbaston, 1875. This bar has never been redhot throughout, the side remote from the fire being always dark and it has been subjected to less heat than the lower bars but to a stronger draft. The bar was fixed in its place by a wrought-iron round pin let in at each end, one of which still remains. This would allow access of air to the interior. In any case the ends have oxidised along the fibres more than the centre has, which has caused expansion and thus produced the separation and bulging at the ends.

3650. Altered steel bar from a furnace bottom.

Communicated by R. Pearce, of the Black Hawk Silver and Gold Smelting Works, Colorado, 1878. Part of the bar is imbedded in consolidated cinder, the consolidation being due to the iron derived from the bar. The bar itself, both in the imbedded portion and the other, shows a concentric structure, a hollow centre and sheaths of scoriaceous matter which are only partly metallic, so that the whole bar is chemically altered and has become of smaller specific gravity. Its diameter is about 1¼ inches.

3651. Decayed half-inch cast-iron plate forming part of the interior tubbing of the upcast shaft of Monkwearmouth Colliery, Sunderland.

It was placed in position at a depth of 180 fathoms from the surface in 1863 and taken up in 1871. It is now entirely turned to rust which is so lightly aggregated that it is like a sponge with a very low specific gravity. Communicated by Lieut. Cundall, R.A.

3652. Scale scraped off the surface of a "Conway tube."

From an area of 2 ft. 4 ins. by 1 ft. 9 ins. Communicated by the London and North-western Railway Company. Analysed by R. Smith, 1869.

3653. Scale rubbed off the surface of a "Conway tube."

From an area of 24 ft. 4 ins. by 1 ft. 9 ins. Communicated by the London and North-western Railway Company. Analysed by R. Smith, 1869.

3654. Altered cast-iron case of the condenser of H.M.S. "Spartan."

From the dockyard at Sheerness. The condenser tubes were of copper and the case within which they were contained was of cast iron. The copper tubes carried steam within and between them and the case sea water circulated. The fragments of the case are nearly or entirely converted with a porous ferric oxide of light specific gravity in the bulk.

3655. Part of an old cast-iron water pipe which had been in use for about 8 or 10 years, at Llanelly, 1863.

It is of unequal thicknesses on the two sides, but has not been sensibly corroded in this part, but shows the spots to which concretions have been attached.

3656. Concretions of hydrous ferric oxide which have formed inside the above pipe to the extent of choking it up.

They are irregular soft brown lumps, showing concentric structure, and on heating them to 110°–120° C. they lose 5·90 per cent. of weight. There is no evidence that they were derived from manufactured iron.

3657. Mass which is supposed to have been an iron rod embedded in scoria from a charcoal furnace of a steel works at the Brades.

It is now a light porous grey material containing glittering particles and unlike either graphite or any compound of iron.

3658. Two rivets from a boiler which exploded at Messrs. Hickman's Works, Staffordshire, in 1856.

On one of these is seen anhydrous, and on the other hydrous ferric oxide, the former from above and the latter from below the water line, indicating that above the water line the boiler had been red hot.

3659. Old cannon ball which has fallen amongst shells and gravel below the sea level.

The cannon ball, about 3 inches in diameter, is partly converted into hydrous ferric oxide, the surface being swollen in parts and divided by irregular cracks, it is surrounded by a dense coat of the same, and beyond this is formed a conglomerate of shells and stones agglutinated by the same hydrous ferric oxide derived by solution from the ball.

3660. Cannon ball exposed for a long period to the action of water by which it has been oxidised and lost its shape, being corroded on one side.

3661. Hook and shackle of coal pit tub left in water for 25 years.

At one of the pits of the Staveley Coal and Iron Company, near Chesterfield, a fire occurred about 1857, and water from the canal was turned in to put it out. The old workings in some parts of this pit have been filled with water for upwards of 25 years. On reopening these levels two trains of pit tubs were found in them; the woodwork was perfectly sound, but the iron was converted into oxide as seen. The links are now all cemented into a mass, which consists entirely of hydrous ferric oxide, which is porous, arranged in concentric bands within, and raised into irregular knots on the surface. Communicated by Mr. Markham 1887.

3662. A key which has lain for some time in the bed of the Thames.

It is coated over with a conglomerate of stones and shells, which are fixed by the impregnated ferric oxide derived from the decay of the key. Communicated by W. Cutter.

3663. Smith's hammer which has been for a long time buried in swampy ground.

Found in making an extension of the Metropolitan Railway Carriage and Waggon Works at Saltley, Birmingham, in 1876. The wood of the handle is unaltered, but the iron head shows the running of the fibres of the iron, both in the body and round the head; they are brought out by weathering. Communicated by F. W. Marshall.

3664. Piece of an old cannon ball taken out of Falmouth Harbour.

It is now loose, porous, crumbling dust of hydrous ferric oxide, with some bright metallic particles scattered irregularly through it.

3665. Rust scaled from the horizontal part of house railings in Lincoln's Inn Fields.

It shows a thickness of at least half an inch, and is highly laminated either after the structure of the original part, or by intermittent formation.

3666. Piece of an old iron gun raised from beneath the sea at Tenby in 1856.

This is changed into a compact black oxide, not at all soft, but brittle under a blow; it shows no concentric or parallel structure.

3667. An old cast-iron shot from a ship at Chatham Dockyard.

The external surface has become oxidised, and a thickness of about $\frac{1}{6}$ inch has mostly pealed off, leaving an irregular core with depressions all over it. Communicated by Col. Pasley.

3668. Old wrought-iron bars out of a dismantled ship, Chatham Dockyard.

One end has in both cases split open, and decayed in laminæ, and one has a conglomerate of gravel formed on it. There was a large quantity of broken scale detached. Communicated by Col. Pasley.

3669. Part of the breach of a cannon showing the touch-hole and tube after firing 530 rounds.

281 rounds have been fired with a 12 lbs. charge, and 249 rounds with an 11 lbs. charge. The tube is eroded in a very irregular way.

3670. Section of old rail after use for 29 years on the Church Fenton and Harrogate line of the North-eastern Railway.

When laid down in 1847 it weighed 65 lbs. per yard, and when taken up again in 1876 it weighed 61 lbs. per yard, but its section shows not the slightest trace of developed lamination. Communicated by T. Harrison.

3671. Section of old single head rail used by the North-eastern Railway Company.

It is a Welsh rail with Crown stamped on it; it originally weighed 65 lbs. to the yard. These rails were laid on the Newcastle and Berwick section on the down main line between Scremerston and Tweedmouth in 1846, and were in use there till 1863. They were then taken out and laid in a siding at Scremerston Lime Works, till they were finally taken out in 1873. They have worn well. Communicated by T. Harrison.

3672. Section of old double head rail used by the North-eastern Railway Company.

It is a Snowdon and Hopkins' rail, weighing 66 lbs. to the yard. The rails were laid on the Kelso branch up line between Velvet Hall and Norham in 1857, and were in use up to 1876, all having been turned but none replaced. They show vertical divisions by intermixed impurities. Communicated by T. Harrison.

3673. Section of old single head rail used by the North-eastern Railway Company.

It is a Hudson rail, weighing 83 lbs. to the yard. These rails were laid on the Berwick Bridge in 1849, and were taken up in 1867 and laid on the Kelso branch down line between Kelso and Spronston, and were still in use in 1876.

3674. Section of old double head case-hardened rail used by the North-eastern Railway Company.

It is a Derwent and Consett Iron Company's rail, weighing 82 lbs. to the yard. These rails were laid on the Newcastle and Berwick section near Chevington station on the up line in 1860, and were still in use in 1876. The rails were case-hardened by the North-eastern Railway Company. The rail has now been reduced to 79⅓ lbs. per yard, or a loss of 2⅔ lbs. in 14½ years.

3675. Specimens illustrating the unintentional welding together of two steel surfaces.

The part with the thicker stem was originally separate from the other, the two being placed together along the surface indicated by the line beyond the collar. They have become welded into one piece so firmly that it has been easier to break the substance of the steel itself than to part them. In a large lathe for turning a special class of work rotation is given to the work by means of a cross shaft. The end of this cross shaft is provided with a flat-ended steel plug (one of the pieces here welded together), which bears into a similar plug (the other piece), rigidly fixed to the frame of the lathe but capable of adjustment. The two steel surfaces are kept in contact, and are made as hard as possible, and are specially provided with an arrangement to keep up the supply of oil. Nevertheless, three or four times during 15 years they have welded together by the heat of friction produced by the rotation. Communicated by J. Taylor, 1880.

3676. Piece of a cast-iron tomb plate erected in Wadhurst churchyard, Sussex, 1613.

It has a superficial coat only of oxide, within it is still solid white iron, probably of Sussex origin.

3677. Piece of an old iron slab from a grave in Burwash churchyard, dating from the 14th century.

This is a portion of the slab mentioned by M. A. Lower in his paper on the Iron Works of the South (Contributions to Literature, p. 97), and figured in Boutell's Christian Monuments. It is certainly cast iron, and, according to antiquarians, there is little doubt of its being 14th century. Communicated by A. Nesbitt.

3678. Rusted iron from an ancient cemetery at Hallstadt, in Austria.

It is rusted to the centre, so that its original nature cannot be ascertained. Communicated by J. Evans.

3679. Portion of one of the iron clamps from the Parthenon at Athens.

This shows a clean blue-white granular crystalline fracture as of wrought iron. Communicated by J. Evans.

MISCELLANEOUS.

3680. Timber from an old tree, found 36 feet below coping level of New Basins, or 30 feet below Trinity high-water mark.

From the Admiralty Works, Chatham. It is perfectly sound. For comparison with iron decayed under similar circumstances.

3681. Wood from a bed of peat at Barking in the sewage tunnel to the Maplin sands. Some 20 or 30 trees seen in situ, in 1866.

3682. Two examples of Irish bog oak in its less altered condition.

Communicated by J. Hawkshaw.

3683. Charcoal which has been heated to a high temperature for several hours.

3684. Charcoal from sugar which has been heated to a high temperature.

3685. Finely divided graphite prepared by Sir Benjamin Brodie's process.

Communicated by Sir B. Brodie.

3686. Anthracite particles collected round the top of a blast furnace at Ystalyfera, near Swansea, Glamorganshire.

The furnace was let down and the blast kept on. In this way the coal is carbonised but has no ore to reduce.

3687. Coke formed where gas leaked from a gas retort, Stafford Gas Works. (1847.)

The same mammillated forms in one specimen and some coarse hair-like processes in the other are shown, and are referred to the decomposition of gas by the heat. Communicated by Mr. Clift.

3688. Coke-like mass from a gas retort, showing mammillated surfaces.

3689. Specimens illustrating the effect of carbon in fusion.

Two pieces of platinum foil have been exposed to a high temperature in small Stourbridge clay pots. One of them was imbedded in fine white sand, and in this case the platinum was untouched by the heat. The other was mixed with carbon, and globules of silicide of platinum have been formed by the extraction of the oxygen of the sand by the reducing action of the carbon.

3690. Specimens of devitrification of glass, illustrating the formation and colouration of slags.

See Percy's Metallurgy, Fuel, &c., p. 33.

These consist of—

A. Three specimens produced during the rapid cooling of sheet glass. These show mere specks scattered throughout the glass. They were produced in the pot of a gas furnace that was cooled as rapidly as possible.

B. Two specimens produced during the slow cooling of sheet glass. These show large nodules 5 or 6 inches in diameter, impinging on each other. They were formed in a furnace that was kept about the melting point of the glass for 10 days and then allowed to die out. The crystallisation has spread from the surface and sides along the bottom of the pot, the central portions of the glass being the last to crystallise.

C. A darker glass with nodules about ½ inch diameter from the "pockets" of a gas furnace.

D. "Ambitty" glass. Obtained from the furnace before the pots are quite worked out. All the above are full green in tint.

E. A specimen consisting of glass of two colours separated by a band of devitrified glass; the one is full green, and contains numerous devitrification centres; the other is blue-green, and contains none. The composition of this sheet glass is, approximately, silica 73 per cent., soda 13 per cent., lime 13 per cent., and alumina and ferric oxide 1 per cent. The specific gravity of the devitrified portion is 2·5823, or a little less than that of the glass, which is 2·5919.

F. Results of experiments on the devitrified glass. The material A N 69 was placed in fragments in a crucible in a large Siemens' furnace. At the end of 12 minutes (in which time fragments of the glassy portion treated similarly had completely melted) it was in a pasty state, giving a fibrous silky appearance on proof B N 69. In 88 minutes more it was entirely converted into the vitreous form, but was full of bubbles. C N 69. (Compare the statement on page 33 of Percy's Metallurgy, Fuel, &c.)

G. The specimen marked A N 61 is formed from vitreous glass of specific gravity 2·5398, by keeping it for 144 hours at a bright red heat and surrounded by sand. It has a specific gravity of 2·4955.

H. Photograph of an hexagonal crystalline plate forming in glass during the process of devitrification, magnified 63 diameters. All communicated by W. D. Herman, St. Anns Glass Works, St. Helens, Lancashire, 1872–3.

3691. Box containing some results of Sir James Hall's experiments on the effects of heat and compression.

These specimens belonged to Faraday, and are labelled by him. Communicated by his widow. They comprise—

A. A specimen of Rowley Rag, accompanied by another specimen of the same which has been melted and then allowed to slowly cool, by which means it has returned again to a crystalline form. The specimen is partly composed of the pot in which it has been fused.

B. A glass tube with the following label "Two specimens in one
" experiment of the effects of H[eat] and C[ompression]. The under-
" most (next the wooden cup) was a piece of common chalk. The other
" (if I am not much mistaken) purified by Mr. Hatchett. They were
" both in tubes of platinum, which metal was fused by the intrusion of
" the fusible metal. The upper specimen, where it has been by that
" means brought into contact with the porcelain, has run much."

C. "Some results of carbonate of lime exposed to H[eat] and
" C[ompression]."

D. "Compound of silex with carbonate of lime obtained by H[eat]
" and C[ompression]."

E. "Chalk turned into a substance like marble by H[eat] and
" C[ompression]."

F. "Pounded limestone formed into stone by H[eat] and
" C[ompression]. An old experiment made in 1799."

G. "Common coal melted under compression retaining its power of
" giving flame."

H. "Piece of wood fused under H[eat] and C[ompression], and re-
" taining its power of giving flame."

3692. Samples of Wedgwood's pyrometer.

Made by the original inventor, Josiah Wedgwood. Each is stamped with the figure 2.

3693. Specimens illustrating the power of Welch's small blast furnace.

A mass of malleable iron melted in a small Stourbridge clay crucible. The iron shows a very remarkable smooth concave fracture. Communicated by Mr. Welch.

3694. Box containing samples of malleable iron which have been melted in Welch's small blast furnace.

In this furnace four ounces of iron are melted in 18 to 20 minutes. The surface of these specimens has been polished with tin oxide, but are otherwise untouched and as they left the crucible. They were obtained by melting iron filings with pure ferric oxide, covered with pounded glass. Communicated by Mr. Welch.

3695. Round balls of ferruginous concretions produced from the water in the lead tanks of the Wortley Silkstone Colliery.

Described by Thomas Andrews to the British Association, 1879, and communicated by him. The water which produces these percolates through the coal strata for 35 yards into a bed of silkstone coal, whence it is pumped up. It always has an acid reaction. It deposits 2·45 grains per gallon on boiling, and it contains in the same quantity 18·16 grains of calcium sulphate, 19·52 grains magnesium sulphate, 1·03 grains potassium chloride, 7·34 grains sodium chloride, and 8·27 grains sodium sulphate. When this water is not previously precipitated but passed direct into the lead tank, at the end of two or three weeks these balls are found, the ironwork of the colliery engine or boilers being at the same time corroded both by the water and the steam generated from it. The water is kept at a temperature varying from 140° F. to 188° F. by steam playing on its surface. The balls have a concentric structure, and the general aspect of hydrous ferric oxide. The analysis gives—

Moisture - - - -	2·30
Loss on ignition - - -	24·40
Silica - - - - -	1·80
Ferric oxide - - - -	62·86
Alumina - - - -	5·43
Phosphoric acid - -	2·81
Lime - - - - -	0·40
	100·00

3696. Boiler incrustation of gypsum.

Characteristic crystals formed in the boiler of the Chyandour Works, North Crofty, Camborne. Communicated by A. K. Barnett.

3697. Specimen illustrating the formation of iron pyrites by solution.

A fragment from a log of wood belonging to the yacht "Osborne" in 1872, in which crystals of iron pyrites may be seen along a flaw. This log had lain for a considerable time in a timber pond at Portsmouth, into which two drains discharged. Communicated by W. Weston.

3698. Crystalline mass of green vitriol.

From the 40 fathom level, Duchy Peın, Newly East, Cornwall. Communicated by Mr. Peto. Produced by the atmospheric decomposition of pyrites, and covered with small excrescences of fibrous crystals of an allied species.

3699. Mass of sulphide of iron which ran down in the form of a stalactite outside a bisulphide of carbon retort.

Communicated by W. Ratcliffe. The colour of the sulphide indicates the presence of some ferric oxide, which is not usual in the ordinary commercial product.

3700. Stalactitic mass of oxide of iron; locality unknown.

It is broken across, and each drop shows radiate crystallisation.

3701. Crystalline slag produced in carrying out "Holloway's process."

It is a silicate of iron, made by blowing protosulphide in a gannister-lined converter, and when all had been oxidised, teeming into a ladle, and allowing it to set. It is a black mass, with thin brilliant rectangular plates standing up in the hollows.

3702. Another block of the same character and origin, showing the irregular shape of the cavities.

3703. A similar specimen, with many of the crystals seen on the flat side.

3704. Slag obtained in the carrying out of the "Holloway process."

This is obtained by exposing tap-cinder to a high temperature with lime, and then pouring it out. It is a failure in the process. It is a minutely scoriaceous mass in which large plate-like black crystals are abundantly formed; the plates being composed of innumerable smaller ones, which are placed edge to edge.

3705. Spence's patent metal formed into a casting.

This material was introduced in 1880. It is made by fusing together a mixture of finely pulverized metallic sulphides, with varying proportions of sulphur. It expands on cooling, thus being specially suitable for casting. It melts at about 320° Fahr. It is very little attacked by acids, and is unaltered in the atmosphere. It is thus adapted for various kinds of fastening.

3706. Compounds of an unspecified alloy with various metals.

A. contains 90 parts of the alloy to 10 parts of gold, the total weight being 98 grains. B. contains 90 parts of the alloy to 10 parts of silver. C. contains 50 grains of alloy to 50 grains of silver, the total weighing 99½ grains. D. contains 50 grains of the alloy to 50 grains of alluminium. E. contains 90 parts of the alloy to 10 of tin.

3707. Bellows for a continuous blast as used in Orissa, Lower Bengal.

It consists of two hemispheres of hard wood side by side, rudely hollowed and each connected with a projecting hollow tube, the tubes on the two sides being carried parallel to each as far as the end of the bellows; the whole is cut out of a single piece of wood. The hollow of the hemispheres is covered with a piece of buffalo hide, with a small piece of string tying it to the end of a bent bamboo fixed into the ground close by. The method of action is as follows: the bamboo acts as a spring, drawing up the string, and with it the leather cover of the bellows to its utmost stretch, while air enters through the central hole. When the hemisphere is thus filled a man places his foot on the hide, closing the central hole with his heel, and throwing the whole weight of his body on to that foot, he depresses the hide, and drives the air out through the tube, while he depresses the bamboo with his hand. This operation being done alternately on the two sides produces a continuous blast. *See* Percy's Metallurgy, Iron and Steel, p. 261, the description being written by Mr. H. F. Blandford.

3708. Pair of circular bellows used in native smelting.

These consist each of a circular block of wood, enlarging towards the top. The upper side is hollowed out for about $\frac{1}{3}$ the depth, and the solid block below is perforated obliquely. The hollow at the top is covered with strong buffalo hide, with a hole in the centre, and tied over a rim at the circumference. These, with a tube fixed into the holes at the bottom and used together, would act in the same way as the last. Locality unknown.

3709. Large conical leather bellows used in native smelting.

At the small end it is fixed to a large but short copper tube of conical shape, at the large end the two sides are sewn tightly to two rods of split bamboo, which at one end are tied together loosely enough to serve as a hinge, and at the other are produced beyond the bellows to serve as a handle, but they can only be separated to about 15°, and the whole bellows then open at the base. It is not obvious how they act. Locality unknown.

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